3.5 Riparian and Wetland Vegetation and Wildlife Habitat

3.5.1 Overview of riparian and wetland vegetation and wildlife habitat restoration goals

The following is a draft list of over-arching goals for vegetation and wildlife habitat in a restored river corridor. This list builds on basic principles of conservation biology, restoration ecology, and ecosystem management (Noss and Cooperrider 1994, NRC 1995, Fiedler and Kareiva 1998, Pickett et al. 1997); ideas developed by the ROST Riparian Vegetation Subcommittee (2001); information contained in the Background Report (McBain and Trush 2002); and riparian and wetland ecological requirements and functions presented in the Restoration Objectives Report (Stillwater Sciences 2003):

- Maintain/restore a diverse assemblage of native species and habitats in a dynamic, self-sustaining system.
- Maintain/restore a mosaic of habitat types, and seral and structural stages, with relative abundance of the various types (e.g., riverwash, riparian forest and scrub, valley oak woodland, grassland, freshwater emergent marsh, seasonal wetlands, alkali scrub and other alkali habitats, and elderberry savanna) similar to the historical condition, within the constraints posed by current and/or likely future land uses, land ownership and critical infrastructure needs.
- Create opportunities and encourage actions to restore a relatively broad riparian and flood basin corridor similar to, but narrower than, that which was historically present along the San Joaquin River throughout the project area.
- Restore river-floodplain connectivity and longitudinal connectivity of riparian vegetation near the channel (without major breaks in the distribution of woody vegetation except where natural conditions prevent establishment of native trees or shrubs) that can provide cover and habitat for a variety of wildlife species.
- Re-introduce elements of the natural disturbance regime to prevent or minimize vegetation encroachment onto active sand and gravel bars, and to "reset" a portion of the riparian vegetation frequently enough to maintain a mosaic of all desired seral and structural stages. The geomorphic analysis (Section 3.1.) indicates that this goal may not be achievable in gravel-bedded areas (i.e., Reach 1), implying that periodic human intervention might be necessary in some cases.
- Promote development of large patches of riparian forest of various types to provide habitat for obligate riparian wildlife species that depend on interior forest conditions (e.g., yellow-billed cuckoo).
- Create or maintain juxtaposition of habitats required by selected wildlife species, such as species that depend on juxtaposition of aquatic, wetland or riparian, and upland habitats to meet various life history stage requirements (e.g., western pond turtle, Swainson's hawk).
- Provide riparian or wetland habitat, where appropriate, that contributes to the maintenance of viable populations of threatened, endangered, sensitive, or other focal species of plants and animals.
- Enhance landscape connectivity between the river corridor and adjacent areas of ecological significance (e.g., wildlife refuges and other protected lands, biodiversity hotspots, adjacent sloughs or tributary channels with existing riparian habitat, wildlife movement corridors).

- Restore and maintain a system that is dominated by native species and is more resistant than the existing system to invasion by and spread of non-native species.
- Restore natural riparian and wetland vegetation types and processes that help improve water quality, promote groundwater recharge, improve nutrient cycling and soil health, support food webs for aquatic and terrestrial wildlife, and are compatible with improved flood protection when combined with levee setbacks in some areas.
- Protect, restore or enhance rare vegetation types.

3.5.2 Assumptions governing development of strategies for riparian and wetland vegetation and wildlife habitat

The goals listed above and their related objectives are based on a number of assumptions about limitations and opportunities throughout the river corridor (Chapter 3 in the Restoration Objectives Report [Stillwater Sciences 2003], Chapter 8 of the Background Report [McBain and Trush 2002], and ROST Riparian Vegetation Subcommittee 2001). Some of the key governing assumptions are:

- If suitable habitat is provided, habitat and many or most of the targeted species will eventually come, although active reintroduction may be desired to speed up the recovery process in general or may be necessary to re-establish populations of certain desirable dispersal-limited species.
- Restoration will take time, but certain actions may be undertaken that are likely to facilitate or speed up the recovery process.
- Immutable natural limitations exist. Some of these include soils, climate, geomorphology, and geologic structure, which will limit the spatial distribution and type of riparian vegetation.
- Vegetation potential varies by reach and subreach.
- Vegetation restoration is spatially limited by alluvial groundwater availability and controlled by thresholds of water and geomorphic surfaces.
- Establishment and succession of riparian vegetation were historically controlled by fluvial geomorphic processes that are associated with the timing, magnitude, frequency, and duration of flows. Riparian hydrograph requirements should be incorporated as foundations for both process-based (natural recruitment) and active (horticultural restoration) riparian restoration strategies.
- The flood control system currently limits vegetation restoration opportunities. Conversely, expansion of the floodway system should provide additional opportunities.
- The hydrological and geomorphic processes that maintain riparian vegetation also benefit a variety of other species.
- There is a physical limit imposed by floodplain, terrace, and bluff topography that will ultimately control the area and width of the riparian corridor.
- The restoration strategies will be designed to establish, enhance, and maintain vegetation on appropriate surfaces for riparian vegetation within the topography of the channel and floodplain (although the practical limits in many reaches are generally constrained by existing levees or constraints on the amount of levee setback that is realistic).
- Adaptive management will be required to meet restoration goals.

3.5.3 Riparian hydrograph components

Riparian tree species along the San Joaquin River have evolved life history strategies that depend on the river's historical hydrology, including the annual cycles of winter floods and spring snow-melt, as well as more infrequent large spring floods. Conceptual models linking riparian tree life history attributes with specific hydrograph components are detailed in the Background Report (see Section 8.7 in McBain & Trush 2002). In order to reestablish woody riparian vegetation along the San Joaquin River, restoration flows will need to mimic natural hydrographs in several key ways.

- High flow peaks, which would mimic to some degree the characteristics of peak flows associated with winter high-volume rain events in the unimpaired hydrograph, will need to be included in the proposed restoration strategies to control vegetation encroachment and prepare seedbeds prior to seedling recruitment flows in wet years (*encroachment prevention flows* and *seedbed preparation flows*).
- High spring peak flows with relatively gradual recession rates during the seed release period for cottonwoods and willows (generally mid-April through June) will be needed during wet years to moisten the seedbeds and induce seed germination at elevations suitable for long-term establishment (*recruitment flows* for seedling initiation).
- Summer and fall base flows are needed to ensure that new seedling cohorts and older cohorts of saplings and mature trees have adequate soil moisture to survive the annual dry season (*maintenance flows*).

These components are described below in terms of the key life history stages that they benefit and the overall effects that they have on vegetation distribution and structure.

To date, much of the riparian research and process-based restoration efforts on have focused on pioneer species such as willow and cottonwood. These species, which release their seeds in spring coincident with the historical snowmelt pulse, are most dependent on riverine hydrology for reproduction and survival and suffer the largest changes in distribution and age structure under severely regulated conditions. For these reasons, the San Joaquin River Riparian Recruitment Model and the riparian restoration hydrograph components focus on these species. Nevertheless, other riparian tree species of interest that occur in the historical riparian zone such as box elder, Oregon ash, white alder, valley oak, and western sycamore disperse their seeds in fall and winter, and rely to varying degrees on river hydrology for initiation and survival (see Section 8.7.3 of the Background Report). Where the restoration hydrograph components will likely affect these species' ecologies, they are discussed below.

Although we generally focus on seedling recruitment, vegetative reproduction also occurs in a variety of riparian species, including willows and cottonwoods. High flows occurring anytime during the year may help to disperse branches or other vegetative fragments to new sites. If these propagules are washed ashore in sites that provide some protection from subsequent high flows, and if suitable soil moisture and receding groundwater levels occur during the root growth period, successful vegetative reproduction may occur. Horticultural restoration techniques for cottonwood and willows that rely on cuttings take advantage of this trait. Although they may occur at other times, the conditions for vegetative propagule dispersal and successful establishment would most likely occur during wet years, in association with managed riparian recruitment flows that would allow the roots of newly deposited cuttings to stay in contact with the slowly declining water table. Some non-native invasive species, such as giant reed, readily colonize new sites through vegetative reproduction. Control of potential sources of such non-native invasive species prior to high flow releases for riparian vegetation seedbed preparation and recruitment may be warranted to reduce the risk of such species colonizing new areas along the river corridor.

3.5.3.1 Indexing Flow Planning to Water Year Type

The volume of water available for a recruitment flow (and therefore the range of potential magnitude, duration, and flow recession) will be largely determined by contemporary hydrologic conditions. Recognizing the stochastic nature of historical floods as well as the extremes of interannual water availability within California's climate, we need to take advantage of years when surface water is abundant to optimize recruitment. The ideal condition is to release a large flow in a wet water year when the reservoir is fairly full (from previous wet or above-normal years). Under these conditions the flow pulse can be sustained to allow moist conditions to persist high on floodplains until seedlings can grow extensive root systems and reach the perennial water table. Under less ideal conditions, lower magnitude flows can be used to encourage recruitment on lower floodplain and bank surfaces. Modulating the magnitude in conjunction with the timing of recruitment flows may be used to achieve a desired landscape distribution of certain species on particular geomorphic surfaces.

Because of these considerations, we recommend a dual approach to flow management for riparian vegetation issues (Table 3.5-1): (1) for wet years, a focus on seedling recruitment and survival (Figure 3.5-1); and (2) in all other years, a focus on preventing vegetation encroachment (Figure 3.5-2).

Table 3.5-1: Primary riparian flow management objectives, by water year type.

Water Year Type	Average Recurrence Interval (years)	Management Objectives
Wet	5	Spring recruitment flows to establish seedlings on lower floodplains, with summer flow conditions sufficient to maintain seedlings on desired surfaces. No fall encroachment prevention flows.
Normal-wet	3.33	No planned recruitment. Recruitment in active channel likely in some years; encroachment prevention flows likely needed in fall to scour near-baseflow elevations. Need to maintain summer water table for young cohorts
Normal-Dry	3.33	
Dry	5	

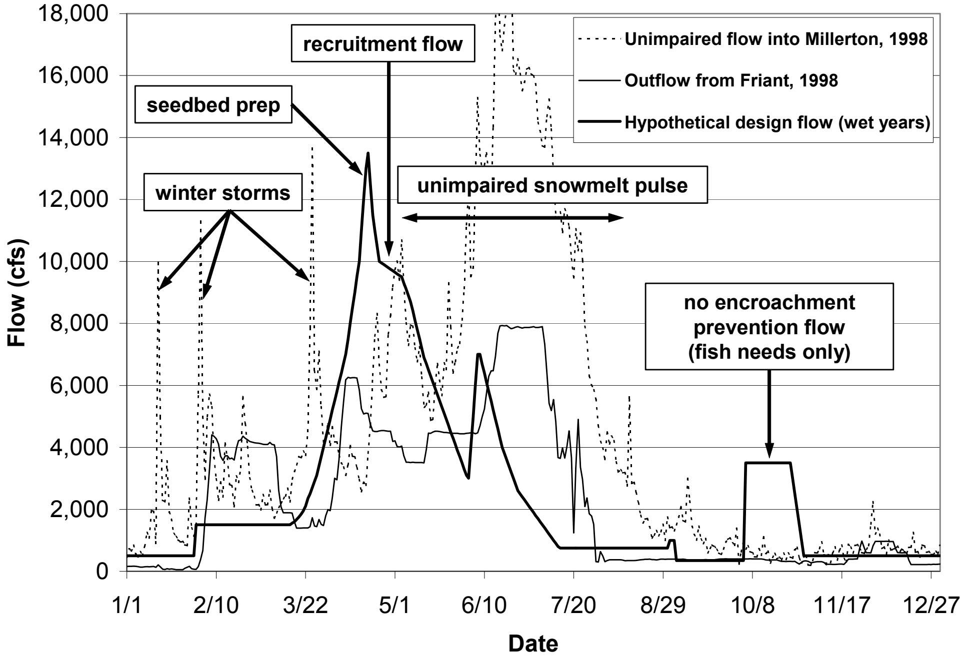

Figure 3.5-1. Hypothetical wet year design hydrograph and example Millerton inflows and Friant outflows from 1998. Riparian recruitment will be encouraged by mimicking unimpaired winter storm pulses (to prepare seedbeds) and spring snowmelt ramp-down rates (to encourage seedling germination and survival).

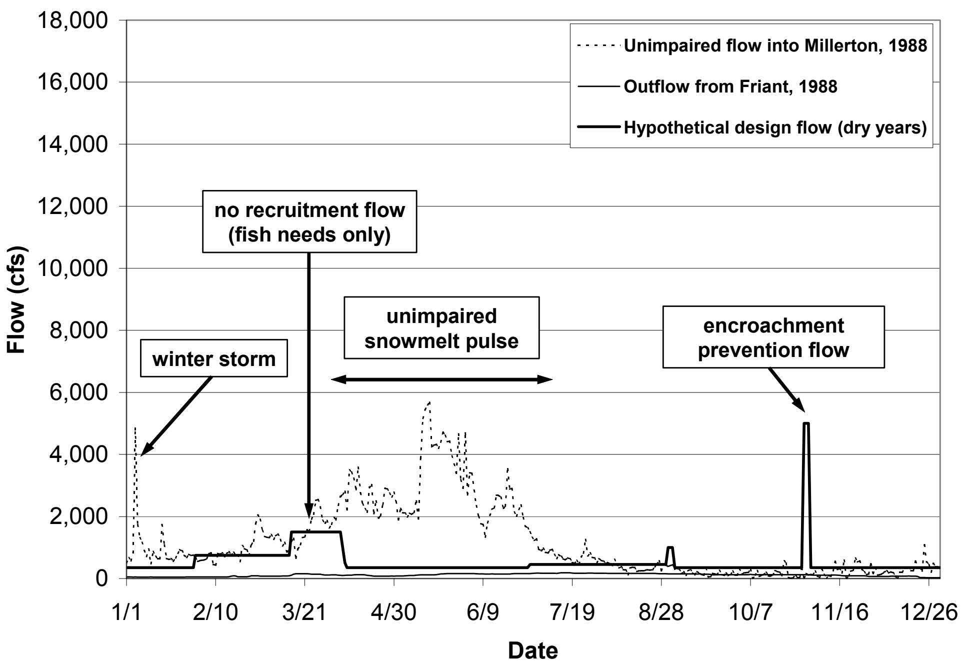

Figure 3.5-2. Hypothetical dry year design hydrograph and example Millerton inflows and Friant outflows from 1988. Seedling recruitment will be not be encouraged in dry, normal-dry, and normal-wet year. The vegetation management priority in these years will be to prevent encroachment at the active channel margin.

Under all scenarios discussed in later chapters of this report, recruitment flows would be planned for wet years only. In early spring, a seedbed preparation flow consisting of a sharp pulse in flow rate would be released, followed by a recruitment flow, which is characterized by a more gradual recession rate. Figure 3.5-1 illustrates a proposed recruitment flow superimposed on an example of an unimpaired wet year hydrograph (Water Year 1986). The seedbed preparation flow would function similarly to the unimpaired winter storm peaks by mobilizing sediments and scouring existing vegetation from potential seedbeds. The recruitment flow would operate analogously to the spring snowmelt pulse, achieving a gradual stage decline rate to allow seedlings to survive at higher bank elevations. The timing, duration, and exact shape of the recruitment flow hydrograph could be adjusted to meet flood control requirements in any particular wet year. The key factor is ensuring that the general rate of stage decline during the recession limb subsequent to the peak flood control releases is gradual enough to support riparian seedling establishment. Another important issue is the timing of the recession limb – if it occurs too late to support recruitment of desired species, a faster rate of decline may be justified (although other ecological objectives, such as groundwater recharge and wetland inundation, should also be considered).

Recruitment flows would not normally be targeted for dry, normal–dry, or normal-wet water years, since reservoir volumes would not likely be sufficient to meet recruitment flow needs and should be conserved to provide baseflows to help recharge water tables in late summer when existing trees would be most vulnerable to drought mortality. In these years vegetation growth near the low-flow channel margin is likely and encroachment prevention flows will likely be needed to clear new growth. These flows correspond to winter storm peaks that are short in duration but high enough in magnitude to mobilize sediments and scour vegetation. In the strategies outlined later in this report, encroachment prevention flows are specified for non-wet water year types, in most cases in coordination with fall flows targeted toward fish objectives. Figure 3.5-2 illustrates a dry year prescribed flow (including the encroachment prevention flow in fall) superimposed on an example dry year unimpaired hydrograph. Note that unimpaired winter storm peaks are still high, but that the spring snowmelt pulse is meager compared to wet years.

No encroachment prevention flows will be prescribed in wet years in order to protect the seedling cohorts that germinated in the spring. In this case, protecting the ecological and economic investment in a recruitment flow takes highest priority.

3.5.3.2 Interannual flow planning

Environmental conditions during the several years after a recruitment event are critical for survival of young cohorts. Seedlings and saplings face a host of potential mortality agents including desiccation (Sacchi and Price 1992; Rood et al. 1998) scour (McBride and Strahan 1984), prolonged inundation (Kozlowski 1997), water table decline (Stromberg et al. 1996), herbivory (Griggs 2003), and disease. As discussed above, the frequency of planned recruitment flows should be initially high to mitigate for possible high mortality events due to these factors. Under an adaptive management framework, intervals between recruitment flows may be increased as more information about mortality agents becomes known.

Variability in the timing and magnitude of recruitment flows is likely to lead to a more diverse and heterogeneous mix of plant species, vegetation types, and habitat structure. We have assumed that such heterogeneity is closer to natural conditions and more likely to promote a variety of ecological objectives than the simpler riparian communities that would likely develop if recruitment flows always occurred at the same time, peak flow magnitude, and recession rate. Adaptive management could be used to find an appropriate approach to designing and implementing spatially and temporally variable recruitment flows. In addition, during the first few years of restoration implementation, a lower magnitude recruitment flow during a normal-wet year might be warranted to test our assumptions about process-based riparian restoration via natural recruitment. In addition, this type of preliminary recruitment test is likely to establish new patches of cottonwood and willows that, when mature, would improve the chances of success of subsequent larger magnitude recruitment flows by increasing the potential supply of seeds throughout the river corridor.

Flow planning in the years after a recruitment flow will likely be critical to cohort survival. High flows with the potential to scour young of the year seedlings should be avoided if possible in the winter after a recruitment event. Subsequent summer spring and summer flows should be adequate to maintain soil moisture during the growing season, but not so elevated as to concentrate root growth near the soil surface and increase vulnerability to desiccation during rapid declines later.

3.5.3.3 Seedbed preparation flows

The seeds of pioneer riparian trees require high light and moisture levels to germinate, and do best on fine-grained mineral soil with little accumulated litter. Under historical conditions, winter floods provided these conditions by scouring banks of vegetation, depositing fine sediments on floodplains, and recharging water tables and soil moisture levels. Restoration efforts will need to include flow peaks adequate to clear herbaceous vegetation and mobilize fine sediment prior to the spring seed-release period to create suitable seed beds. To conserve water and make best use of potentially limited fine sediment, seedbed preparation flows should be implemented only in years when subsequent recruitment flows are planned. Seedbed preparation flows that precede recruitment flows by only a few days or weeks are likely to be more successful, since the timing would reduce the risk of non-native annuals becoming established in time to outcompete willow and cottonwood seedlings. Larger substrate size in Reach 1 (and consequent higher critical shear stresses) may prevent adequate seedbed formation in almost all years. Species such as valley oak, box elder, and sycamore have larger seeds with more stored resources to allow growth under low seedbed light levels, and may not require mineral soil and extensive scour to the degree that willows and cottonwoods do. Winter or early spring seedbed preparation flows may benefit fall and winter dispersing species through increased dispersal of propagules onto floodplains.

If managed seedbed preparation flows are insufficient to create appropriate seedbed conditions through scour or sediment deposition in appropriate locations, human intervention may be required periodically to set the stage for natural recruitment processes. The Adaptive Management Report (Stillwater Sciences 2003) will discuss this issue in more detail.

3.5.3.4 Recruitment flows

For the purposes of this project, recruitment flows refer to controlled releases that occur during the spring seed release and dispersal period for pioneer riparian trees (particularly Fremont cottonwood and Gooding's black willow). These flows are designed to mimic in some respects the historical snowmelt pulse. Biologically important aspects of recruitment flows include flow frequency, timing, magnitude, duration, and rate of stage decline. The importance of these hydrograph attributes for pioneer riparian tree seedlings is described below. For lower floodplain species such as white alder and box elder that disperse seeds in fall and winter, flow timing is less important because their seeds survive longer, but all other issues apply. High floodplain species such as valley oak and western sycamore may be more dependent on rainfall events and other climatic or stochastic events for establishment (see Section 8.7.3 of the Background Report [McBain and Trush 2002]) than on spring snowmelt pulses.

Frequency

For any biological population to be self-sustaining, viable offspring must be produced in adequate numbers during the adults' reproductive lives to offset deaths due to multiple causes. Riparian trees live in a dynamic physical environment where catastrophic disturbance from floods (and in some cases fire) can severely limit the abundance and distribution of fecund adults. Willows and cottonwoods also tend to have short life spans, typically a century or less. For these species' populations to be sustainable, new cohorts of these trees need to be created at short enough intervals to replace adults killed by disturbance or senescence. Research on riparian forest stands in western North America indicates that successful recruitment events typically occur after flows representing a 5- to 10-year recurrence interval (Bradley and Smith 1986, Cordes 1991, Reid 1991, Howe and Knopf 1991, Stromberg et al. 1991, Stromberg et al. 1993, Rood et al. 1997, Scott et al. 1997, Cordes et al. 1997, Rood et al. 1998). Though some cite intervals as short as 3 years (Baker 1990, Howe and Knopf 1991) and some as long as 30 to 50 years along some non-meandering rivers (Hughes 1994, as cited in Chapter 8 of McBain and Trush 2002). Recruitment flows on the San Joaquin River should be timed initially on the lower end of that range to ensure viable seedling cohorts soon and to account for potential large-scale mortality events. However, the potential for a recruitment flow in any particular year will be constrained to a large degree by factors such as the magnitude and timing of winter rainfall, prior year hydrology, and reservoir operational issues.

Timing

For willows and cottonwoods, whose seeds are viable only for several weeks, seed release must coincide with wet conditions and seedbed availability to produce a successful cohort. Appropriate flow timing is therefore the first condition necessary for a successful recruitment flow, and constraining flood timing will conceivably benefit some species over others. The annual chronological order of spring seed-releasing species is as follows: arroyo willow, Fremont cottonwood, black willow, and narrow leaf willow. Generalized seed dispersal periods are graphed in Figures 8-36 through 8-39 of the Background Report (McBain and Trush 2002). Recruitment flows should be targeted from mid-April to late-May to improve cottonwood recruitment, and mid-May to late June to benefit black willow. Flows prior to mid-April will likely miss the seed release window for these species (but may benefit arroyo willow, currently a less dominant species within the San Joaquin River riparian corridor but one that is common along portions of the Merced and Tuolumne rivers), and later flows will likely benefit narrow leaf willow, which releases seeds throughout the summer. This latter species also benefits from elevated summer baseflows in the absence of spring peaks because of its vigorous sprouting ability.

Magnitude

The magnitude of a spring flow pulse determines how high on the banks and floodplain the river stage reaches, and therefore, how high and broad the areas of potential recruitment occur. As discussed above, willow and cottonwood seedbeds need to have moist, fine-grained mineral substrates for germination to be successful. If winter flow releases have adequate capacity to scour vegetation and deposit sediment, spring recruitment flows need not have the same magnitude and can function similarly to a flood irrigation treatment. However, the relative timing of the seedbed preparation and recruitment flows must be considered, since many non-native grass species germinate and proliferate in late winter and early spring, and may invade prepared seedbeds before riparian tree seedlings can establish. In these cases, altering the timing of the winter releases or mechanical removal may be necessary prior to recruitment flows.

Duration
Recruitment flow peaks should be of sufficient duration to fully saturate the seedbed substrate (down to the perennial water table) and allow for floating seeds to raft up onto floodplain surfaces. Most willow and cottonwood seeds germinate within 24–48 hours after wetting (Pelzman 1973; Guilloy-Froget et al. 2002; Stillwater Sciences, unpublished data), so flows likely need to be maintained several days to a week (maximum) at peak levels to induce germination. Since brief flow peaks will limit the quantity of seeds rafted onto floodplains from upstream areas, peak flows should occur during peak seed release, when waterborne seed density is highest, to most efficiently collect rafted seeds. The restoration hydrograph should be designed to maintain peak flow for several days followed by a gradual initial ramp down in order to concentrate and deposit these seeds at appropriate higher elevation surfaces. With shorter peak flow duration and more rapid ramp down rates, seed deposition will occur at lower elevations as long as viable seed is available (Rood et al. 1998).

Rate of stage decline
Because willows and cottonwoods are phreatophytic (i.e., their roots must maintain contact with a perennial water source), decline rates recruitment flows must be gradual enough to prevent desiccation of newly germinated seedlings. A given flow ramping rate will produce different stage recession pattern depending on cross-sectional geometry, but most river corridors, including the San Joaquin River's, exhibit dominant channel geometries along large reaches, so some simplifying assumptions may be possible. Spatially-explicit restoration approaches such as the San Joaquin River Riparian Recruitment Model are most valuable, because stage-discharge relationships can be modeled independently at each cross section.

Research on a variety of cottonwood and willow species over the last fifteen years have produced a consensus of 1 to 1.5 inches/day as the survivable rate of water table decline (McBride et al. 1989; Segelquist et al. 1993; Mahoney and Rood 1992, 1998; Amlin and Rood 2002). However, it is important to point out several issues that may qualify these values. Most of these studies grew seedlings in controlled tank environments at higher latitudes than the San Joaquin Basin, so field vapor pressure deficits (and therefore drought stresses) may be underestimated for the study reach. Furthermore, most of these studies grew seedlings from willow and cottonwood cuttings, which are more resilient than newly germinated seedlings. Lastly, several of these studies held the water table constant for several days to several weeks before the drawdown treatments began, also moderating the stresses that would be expected under field conditions. A recent manipulation experiment of Fremont cottonwood, black willow, and narrow leaf willow seedlings found that water table declines of one inch or more resulted in 80% mortality within 60 days, even when the water table was maintained near the soil surface for several weeks before drawdown (Stillwater Sciences, unpublished data). It therefore seems prudent to assume that the published rates are best-case scenarios; actual management actions may want to use more conservative rates.

A series of modeling runs using the San Joaquin River Riparian Recruitment Model indicated that flow recession rates of 100 to 300 cfs/day generally yielded predicted recruitment areas close to the maximum possible, while recession rates greater than 300 cfs generally showed more substantial decreases in recruitable area (see Section 3.7 in the Restoration Objectives Report). Though an extensive sensitivity analysis of various stage decline rates was not attempted, model results indicate that at most cross sections, rates in the range of 100 to 300 cfs/day were sufficient to prevent desiccation under the assumed 0.1 foot/day maximum root growth rate. Additional sensitivity analysis indicated that the model is relatively insensitive to root growth rate, at least under the conditions assumed for modeling purposes (see Restoration Objectives Report, Section 3.7, for more details on the model [Stillwater Sciences 2003]).

3.5.3.5 Seedling maintenance flows

During the summer following a large recruitment event, drought is a major factor potentially limiting seedling survival. If the water table and its capillary fringe recede below the rooting zone of newly established seedlings, widespread desiccation may kill the entire cohort. Field and experimental studies report that successful seedling establishment is often limited to sites where the water table reaches a depth of no more than 2–8 feet at the end of the growing season; however, the specific elevation range may vary with river size and various local or regional factors (McBride and Strahan 1984; Mahoney and Rood 1992, 1998; Segelquist et al. 1993; Stromberg and Patten 1996; Scott et al. 2000). Though data are not available on later dispersing species, desiccation is a threat and the same rooting depth range appears reasonable. Data from the Merced River on the relative elevation of established riparian trees suggests that most native species recruit successfully somewhere in the range of 2–8 ft above summer baseflow water surface elevation (which is assumed to represent local groundwater levels near the channel where the surveys were conducted) (see Table 3-14 and Section 3.3.4 in the Restoration Objectives Report).

Modeling results from the San Joaquin River Riparian Recruitment Model (see Appendix E-1 and E-2 for modeling results for each strategy; see Section 3.3.8 in the Restoration Objectives Report for further description of the model) indicate that recruitment flows of 5,000 to 8,000 cfs can potentially lead to successful seedling recruitment on geomorphic surfaces within this 2–8-ft relative elevation zone (although the specific elevational range of the recruitable zone will vary somewhat by reach and individual cross section due to local variations in topography and stage-discharge relationships). Based on the literature, Merced River data, and the San Joaquin River Riparian Recruitment Model, we assume that successful recruitment of native riparian species is most likely to occur in the range of 2–8 feet above summer baseflow water surface elevation. Under Strategies 2 and 3, higher magnitude managed releases would be possible, providing the possibility of recruiting native riparian species on somewhat higher surfaces (approximately 8–10 feet above summer baseflow). Under all three strategies, it is likely that many native riparian tree and shrub species can be established on many higher elevation surfaces outside of the flow recruitment zone (generally ranging from 8 to 15 or 20 feet above summer baseflow water surface elevation) if soils conditions are suitable and horticultural techniques are used to plant and maintain individual trees and shrubs until their roots can tap into the local shallow groundwater table (e.g., Griggs and Golet 2002).

On the San Joaquin River, flows during the summer following a flow recruitment event will need to maintain the riparian water table at a level sufficient to prevent desiccation. Summer flow levels need to be planned in coordination with recruitment peak flows using modeled stage-discharge relationships (to ensure that the difference between maximum and minimum stage at most cross sections does not exceed 2–8 feet), as well as in coordination with fish and geomorphic restoration objectives.

Maintenance flows may also be needed in losing reaches to ensure that the roots of older saplings and established trees of phreatophytic riparian species maintain contact with ground water during the summer and fall dry season, particularly if summer and fall ground water levels are greater than 10-20 feet below the ground surface (Griggs and Golet 2002, JSA 2002).

3.5.3.6 Encroachment prevention flows

Vegetation encroachment occurs on regulated rivers when stable flow conditions encourage the establishment of vegetation in the formerly active channel and annual flow peaks are not sufficiently forceful to remove plants from bars and banks. This phenomenon has been documented widely throughout western North America (Johnson 1994, 1998, Ligon et al. 1995), as well as for the San Joaquin River and its tributaries (McBain and Trush 2002; Stillwater Sciences 2002). Flow releases designed to scour existing vegetation need to be incorporated into a long-term management plan for the San Joaquin River, especially following a series of dry years when encroachment can be expected to be most severe. Scouring flows can be implemented as part of a seedbed preparation flow, since the timing and magnitude necessary for both purposes would be the same. A scouring flow should be avoided in the fall immediately following a recruitment event, however, to prevent potential destruction of the new seedling cohort. Hence, encroachment flows are not included in wet year hydrographs, but they are included in the hydrographs for every other water year type.

Encroachment prevention flows may achieve their purpose by causing mortality of seedlings on lower surfaces on channel bars due to scour, inundation or sediment deposition. Managed flow release constraints of Friant Dam would likely limit the effectiveness of encroachment flows in the gravel substrates of Reach 1. In the sand-bedded region (Reaches 2 – 5), we assume that encroachment prevention flows of 5,000 cfs are likely to achieve the desired objectives. Observations along the sand-bedded reach of the lower Tuolumne River in 2002 suggest that 3,500 cfs peak flows were sufficient to kill seedlings within 2 ft vertical elevation of summer baseflow water surface through scour, sediment deposition (up 0.5 ft of sand deposited in some sites), or prolonged inundation) (Stillwater Sciences, unpublished data). Based on the Tuolumne River observations, and an added "margin of safety," we have assumed that 5,000 cfs flows should be capable of preventing or greatly reducing encroachment by woody vegetation. This assumption needs to be confirmed through monitoring and adaptive management.

3.5.4 Approach used to develop strategies for riparian and wetland vegetation and wildlife habitat

In order to develop reach-specific strategies for improving conditions for riparian and wetland vegetation and wildlife habitat, areas were identified that, through various restoration activities, would promote the "target" developed for each vegetation type described below in Section 3.5.5. Our governing assumptions in developing strategies can be generalized as follows:

1. Preserve and enhance the diversity of natural plant types along the river corridor.
2. Expand the existing riparian corridor to improve conditions for fish (e.g., through stream shading), wildlife (e.g., promote a wildlife movement corridor), and water quality (e.g., widen riparian buffer zones to reduce anthropogenic sources of nutrient inputs to the river).
3. Provide larger habitat patches at strategic locations along the river corridor that would benefit wildlife and provide a seed/propagule source for natural recruitment of native riparian species.
4. Provide habitat connectivity to adjacent natural areas, such as sloughs, vegetated bypasses, tributaries, and refuges, in order to improve landscape-level linkages to the mainstem San Joaquin River.

The methods employed for determining the extent of strategy-specific actions (discussed in Chapters 4 through 7) included a combination of San Joaquin River Riparian Recruitment Model predictions and a more traditional opportunities and constraints analysis. The San Joaquin River Riparian Recruitment Model results were used to quantify potential naturally recruitable areas within each reach under each of the three Strategies (see Appendix E-1 and E-2 for modeling results for each strategy; see Chapter 3 of the Restoration Objectives Report [Stillwater Sciences

2003] for a detailed description of the model). In reaches where the existing riparian vegetation within the potential recruitable area is currently sparse, horticultural restoration of small parcels is proposed to “jump start” the natural recruitment process by providing seed/propagule sources throughout the corridor. Additionally, actions proposed for certain reaches include horticultural restoration of wetland and mesic riparian plant species within the potential recruitable area, to improve invertebrate habitat, increase vegetative cover for juvenile fish rearing, and minimize woody riparian species from encroaching into the active channel.

A preliminary opportunities and constraints analysis was used to delineate parcels outside of the potential recruitable area by examining existing conditions of the project area using aerial photographs and GIS maps of inundation, topography, soil salinity/texture, vegetation, and current land use. This analysis allowed us to identify parcels at a coarse scale that are potentially suitable for horticultural restoration (i.e., site conditions could support restored vegetation with a minimum of maintenance), in order to develop appropriate restoration strategies for each reach. Appendix D provides example maps illustrating some of the basic mapped information used in the preliminary, coarse-scale opportunities and constraints analysis. It should be emphasized that more site-specific information (e.g., data on groundwater/surface water interactions, local soil conditions) and communication with invested landowners will ultimately be necessary before a detailed, site-specific restoration plan can be developed to implement the strategies discussed in Chapters 4 through 7.

The majority of selected parcels fell within existing or proposed levees/canals. Parcels outside existing levees were identified primarily to promote landscape-level habitat connectivity or improve diversity of vegetation by restoring higher elevation vegetation types such as oak woodland/savanna. Parcels were included or excluded from a particular strategy depending on the focus and primary considerations for that strategy (the focus of each strategy is discussed in Chapters 4–7).

Each of the strategies discussed in Chapters 4 through 7 include reach-specific activities for improving conditions of identified parcels for riparian vegetation and wildlife. These activities can be generalized into six categories: (1) preservation of existing high quality or rare habitats, (2) appropriate flow regime to promote natural recruitment, (3) floodplain re-grading to promote natural revegetation, (4) horticultural restoration, (5) improving landscape-level linkages along and to the river corridor, and (6) management of non-native invasive species. The sections below describe the benefits and typical implementation methods for each of these six activities. This information will be referenced throughout Chapters 4 through 7. The project proponents will need to work closely with the communities within and adjacent to the planning area to develop effective, locally supported restoration projects that balance the needs of the community and landowners with ecosystem restoration goals.

3.5.4.1 Preservation of existing habitat

Preservation of existing ecologically intact lands can be a more cost-effective means of meeting restoration goals for vegetation and wildlife than restoring degraded land. Whereas horticultural restoration requires time and significant maintenance and monitoring effort to restore the natural processes and ecosystem functions of the area, preservation assures that existing high-quality habitat (e.g., a mature stand of oak woodland) is, at a minimum, protected from further degradation and/or destruction. It also supports a core area of intact habitat upon which to build further restoration efforts, providing seed/propagule sources for horticultural restoration, and a source population of wildlife that can colonize the adjoining restoration areas as they develop over time.

Conservation easements, fee-title purchases, partnerships between government agencies and nonprofits, and incentive programs provide a mechanism for preserving ecologically or agriculturally significant resources on private property while also supporting economic productivity. Through easements and incentives, private property owners maintain title to the properties and their riparian water rights, while forfeiting some potential uses of that property in return for compensation. This ensures that ecologically valuable functions remain intact.

Conservation easements can be funded through a variety of public and private sources and can be administered by both government agencies, such as the Wildlife Conservation Board, and non-governmental agencies, such as land trusts and land conservancies. In addition to the compensation provided to the landowner for purchase of the easement, conservation easements can reduce property tax burden by reducing the assessed property value. Additionally, easements can be flexible enough to accommodate the needs of all parties. For example, the duration of a conservation easement can be determined on a case-by-case basis, depending on the interests of the funding source and the landowner. Typical sources will provide funds for easements lasting from 10 years to perpetual easements.

Preservation efforts should attempt, whenever possible, to build on existing easements/public lands in order to maximize the benefits of habitat connectivity. The Trust for Public Land (TPL), in a joint venture with the nonprofit San Joaquin River Parkway and Conservation Trust (Parkway Trust), has been working since 1992 to help create the 22-mile San Joaquin River Parkway north of Fresno. TPL and the Parkway Trust work in cooperation with the private sector and public agencies, including the San Joaquin River Conservancy, Wildlife Conservation Board, Bureau of Reclamation, Department of Fish and Game, and Cal Trout, to preserve river lands for natural reserves, parks, and open space. The parkway eventually will comprise some 6,000 acres or more of protected land, trails, and river access points along the San Joaquin River below Friant Dam in the Fresno–Madera region (San Joaquin River Conservancy 2000, as cited in TPL 2001). To date, TPL and the Parkway Trust have acquired and conveyed Rank Island to CDFG, as well as the Wildwood Property and the Jensen River Ranch to the San Joaquin River Conservancy. Rank Island, with its approximately 270 acres of wetlands and riparian forest, is an urban nature preserve that provides habitat for deer and bald eagles, and also serves as a large heron and egret rookery. The 22-acre Wildwood Property, directly adjacent to Highway 41, provides critical public access to the river in Madera County. Finally, the 156-acre Jensen Ranch ties Woodward Park to the San Joaquin River in the heart of the San Joaquin River Parkway. These efforts have secured key riparian properties for habitat restoration (TPL 2001).

The 26,609-acre San Luis National Wildlife Refuge complex is a mixture of managed seasonal and permanent wetlands, riparian habitat associated with 3 major watercourses, and native grasslands, alkali sinks, and vernal pools. The refuge is primarily managed to provide habitats for migratory and wintering birds. The largest concentration of mallards, pintails, and green-winged teal in the San Joaquin Valley are found here. One of only 22 herds of the indigenous tule elk lives here, as are a variety of endangered, threatened and sensitive species. This refuge is a major sanctuary for mallards, green-winged teal, ring-necked ducks, and northern pintails, an also supports a large diversity of raptors. The Refuge is a remnant of San Joaquin riparian bottomland and floodbasin habitat. Existing marsh basins and riparian channels retain a natural topography, but must be artificially flooded and maintained via labor-intensive manipulations to create desired habitat conditions. The diverse mixture of habitats—riparian, wetland, native grassland, vernal pools, alkali scrub, etc.— attract a wide diversity of species, including a number with threatened and endangered status (USFWS 2003).

Farther downstream, the James J. Stevinson Corporation is in the process of placing conservation easements on nearly 9,000 acres of its landholdings along the eastern side of the downstream portion of Reach 5, at the confluence of the Merced and San Joaquin rivers in Merced and Stanislaus counties. The easement lands are adjacent to and will serve to expand the San Luis National Wildlife Refuge and the North Grasslands State Wildlife Area. By placing the land under easement, the Stevinson Corporation will retain riparian water rights, create opportunities for habitat enhancement, and be eligible for tax benefits (Riviere 2000).

3.5.4.2 Promoting natural recruitment

Central Valley riparian forest initiation begins with the colonization of bare, moist alluvial surfaces by seedlings (typically Fremont cottonwoods, willows and other fast-growing species) following large flow events that meet the life history requirements of these species (see Section 3.5.2). These pioneer species are physiologically adapted to the highly variable hydrologic and geomorphic regimes of alluvial river floodplain systems. Providing flow conditions necessary for the natural recruitment of riparian vegetation will provide the physical forces, such as flooding, scour, and sediment deposition, that strongly influence riparian plant species composition, distribution, and physical structure and serve as major drivers of riparian community succession (see Section 8.7 of the Background Report [McBain and Trush 2002] and Section 3.3.7 of the Restoration Objectives Report [Stillwater Sciences 2003] for a more thorough discussion of riparian plant recruitment and succession). This, in turn, enhances the quality of the established habitat, maintains a functional riparian corridor width, and dramatically reduces the need for horticultural restoration and associated maintenance, which can be a costly and labor-intensive undertaking.

To enhance the ability of vegetation to recruit naturally, release of recruitment flows is included as a major component of each of the three strategies discussed in Chapters 4 through 7. The rationale for and more detailed discussion of these flow releases are described in Section 3.5.3. Typically, these flows should be scheduled every five to ten years to provide a regular cycle of disturbance and recruitment. Variation in the timing, magnitude, and duration of peak flows will help to promote diversity, complexity, and extent of the recruited vegetation type. It is important to note that many non-hydrologic factors, including shade tolerance and other competetive abilities, proximity to seed source, intensity of herbivory, and presence of disease, contribute to the success of plant establishment and species distributions within riparian zones.

Flow release schedules should be prioritized based on the desired outcome for the distribution and diversity of species on various floodplain surfaces. For example, flow releases during late April to mid-May would support recruitment of Fremont cottonwood, while later flow releases would benefit black willow and narrow leaf willow, based on our understanding of their peak seed release both in the San Joaquin River mainstem and its major tributaries. Flows with higher magnitude and duration would increase the area in which potential recruitment occurs. The San Joaquin Riparian Recruitment Model was used as a planning tool to help design restoration hydrographs and to predict the potential amount of recruitable area that might be provided under each of the three strategies (see Sections 5.3, 6.3, and 7.3 for a summary of the modeling results, and Appendix E-1 and E-2 for more detailed results). The model is described in more detail in Section 3.3.8 of the Restoration Objectives Report.

3.5.4.3 Riparian and wetland considerations during floodplain reconstruction

As much as possible, the goal is to re-create self-sustaining riparian processes within the managed flow regimes, in order to minimize the need for more costly and labor-intensive methods such as horticultural restoration. Potential actions to restore riparian processes include re-scaling the channel cross-section under managed flow regimes to create physical conditions conducive to natural recolonization by native vegetation (natural recruitment is discussed above in Section 3.5.3.2). Floodplain reconstruction can be designed to provide topographic variation with zones that experience different inundation durations and flood recurrence intervals. This would create topographic and hydrologic complexity necessary for natural establishment of a diversity of plant communities. For example, creating shallow depression areas that mimic to some degree the abandoned channel features found in alluvial river systems would provide recruitment areas for cottonwood and other riparian species. This technique has been successfully implemented on the Truckee River (S. Rood, pers. comm., 2002) and on Clear Creek (McBain and Trush et al. 2000). Higher elevation surfaces that would support valley oak woodland could be created if appropriate fill material were available (e.g., non-saline soils with low clay content).

Creation of seasonal wetlands could be implemented opportunistically, depending on where heavy equipment is being used for channel reconstruction. Surfaces could be further graded where groundwater levels would support complexes of perennial open water and wetlands. These re-constructed open water and wetland areas would mimic oxbow lake conditions that naturally occurred along the San Joaquin River (see Chapter 8 of McBain and Trush 2002).

Management of non-native invasive plant species must be considered when planning floodplain re-grading activities, including removal of these species from regraded areas, and monitoring for new invasion into areas disturbed by re-grading activity. See Section 3.5.4.6 for further discussion of management of non-native invasive plant species.

3.5.4.4 Horticultural restoration

Horticultural restoration can enhance the benefits of the naturally recruited riparian corridor by increasing the width of the corridor, providing an important initial seed and propagule source to stimulate natural regeneration, and hastening the establishment of riparian habitat patches along the river corridor, which increases the diversity and complexity of available habitat for wildlife. This restoration activity is primarily recommended in areas where there will be significant floodplain reconstruction and/or levee setbacks under all strategies (this includes Reaches 1, 2 and 4), and in strategic areas throughout the project area where horticultural restoration is both likely to be sustained (given site conditions identified during the opportunities/constraints analysis) and likely to provide plant-community-specific benefits. These benefits are summarized below.

Areas graded to levels appropriate for floodplain rearing will likely experience some natural recruitment based on the proposed flow regime, but should be horticulturally restored with wetland and mesic riparian plant species to promote suitable habitat conditions for terrestrial and aquatic invertebrates (an important food source for fish when vegetated floodplains are inundated), minimize the risk of woody riparian species encroaching into the active channel, and reduce the threat of invasion by non-native plant species (further recommendations for eradicating and controlling non-native invasive plant species are included in Section 3.5.4.6). Horticultural restoration of communities whose historical extent has been greatly diminished in the project area through human disturbance (e.g., habitat loss and fragmentation, and land use change), such as freshwater wetlands and valley oak woodlands, increases the diversity of available habitat important for many wildlife species. The habitat value of these community types is discussed in more detail in Section 3.5.5. The benefits of horticultural restoration to hasten development of landscape-level linkages between the San Joaquin River mainstem and adjacent natural areas (e.g., sloughs, vegetated bypasses, and refuges) is discussed in more detail under Section 3.5.4.1.

The main plant communities that are the focus of horticultural restoration efforts recommended for the San Joaquin project area under the various strategies include seasonal perennial wetlands, riparian forest and scrub (including willow, cottonwood, and mixed riparian vegetation types), valley oak woodland/savanna, and to a limited extent, elderberry savanna. Appropriate plant species for horticultural restoration will vary with desired target habitat conditions and local site factors. Freshwater marsh and seasonal wetland restoration may include tules and bulrushes, sedges, cattails, pondweed, and rushes as dominant species. Riparian forest and scrub restoration may include a variety of mature tree and shrub species, such as Fremont cottonwood, Gooding's black willow, Oregon ash, button bush, alder, red willow, arroyo willow, box elder, valley oak, and western sycamore. Plants of understory species such as mugwort, wild grape, native blackberry, wild rose, and Mexican elderberry may also be desired to promote floristic and vegetation structural diversity and to provide key habitat elements for certain wildlife species (e.g., mugwort appears to be important for nesting success of several riparian bird species in Sacramento River riparian forests [Golet et al. 2003, Small 2000, Griggs and Golet 2002]) (see Section 3.5.5 for more detail on composition and distribution of these community types).

Horticultural restoration can be implemented in a variety of ways, including direct seeding (direct planting of seeds such as acorns, or dispersal of seed over the surface via hydromulching, etc.), use of donor seed banks, or direct planting of propagated nursery plants and vegetative fragments (cuttings). The planting of propagated nursery plants or vegetative fragments (cuttings) is a common practice at restoration sites (Middleton 1999). The revegetation of some lands following their restoration can occur spontaneously, but others may require massive intervention to eradicate non-native invasive plants and irrigation to promote establishment of restored plants. Horticultural restoration can be combined with land preservation and conservation easements, or may be conducted on already protected public and private lands.

Revegetation should be compatible with restored hydrologic and fluvial processes to promote long-term success. Riparian plant species should be planted to correspond with specific geomorphic surfaces that are inundated by specific flood recurrence intervals (McBain and Trush 2000). Natural conditions of species diversity and structural diversity are generally the desired restoration target, which may require planting a mix of woody overstory species and shrubby and herbaceous understory species, to achieve the desired target. Horticultural restoration should be done with locally collected seeds and seedlings to preserve the genetic integrity of the local population (CNPS 1989, as cited in CALPIF 2002).

Potential horticulture restoration sites may be prioritized according to the likely success of regeneration and viability of transplanted individuals (i.e., where site soil, elevation, and inundation conditions are most likely to support the restored vegetation with minimal maintenance), and by their potential to connect to patches of existing riparian habitat (CalPIF 2002, RHJV 2000).

The following are additional considerations for developing horticultural restoration projects.

- Plan restoration efforts by selecting patch size, configuration, and connectivity of riparian habitats to adequately support the desired populations of riparian-dependent species (RHJV 2000).
- Balance efforts directed at planting and maintaining woody overstory species with those focusing on restoring a native herbaceous understory, in order to maximize benefits to multiple species (Griggs and Golet 2002). For example, songbird distribution in restored riparian areas was largely dependent on the understory component (Small 2000, as cited in Griggs and Golet 2002). Managing riparian and adjacent habitats to maintain a diverse

and vigorous understory and herbaceous layer can be particularly important to birds during the breeding season (RHJV 2000).

- Maintain a diverse age structure in riparian vegetation. This diversity can be promoted through protecting seedling and sapling trees; retaining decaying or dead trees, limbs, snags, and mistletoe (to provide habitat for cavity-nesting birds and other wildlife, and retaining large trees whenever possible (for habitat and food production) (CalPIF 2002). Retaining at least some existing trees on restoration sites and planting around them can provide habitat for birds that require mature trees (RHJV 2000).
- Conduct vegetation restoration with an eye towards benefiting healthy bird populations, by restoring understory components, restoring upland habitats in conjunction with adjacent riparian habitats, and restoring a mosaic configuration of a diversity of vegetative types (CalPIF 2002). Other methods of vegetative restoration to enhance avian populations include: avoiding the construction or use of facilities and pastures that attract and provide foraging habitat for European starlings and brown-headed cowbirds (a parasitic bird species); limiting restoration activities and disturbance events such as grazing, prescribed fires, firewood harvesting, disking, and herbicide application to the non-breeding season; and managing restoration activities at the landscape level (CalPIF 2002, RHJV 2000).
- Revegetate in patches rather than in rigid grid spacing (McBain and Trush 2000), to mimic the natural patchiness of historical riparian forests and create interior habitat for wildlife.

Recommendations for restoration activities directed at improving the condition of riparian vegetation and wildlife habitat by strategy were developed for each reach by: (1) identifying the potentially recruitable area under the strategy-specific flow regime, (2) identifying parcels that are located within the existing levees but likely to be outside the naturally recruited area under the recommended flow regime, (3) conducting an analysis of opportunities and constraints (based on aerial photographs and GIS maps of inundation, topography, soil salinity/texture, existing vegetation, and current land use) to determine the suitability of these parcels for other restoration activities (e.g., preservation, horticultural restoration); and (4) designating all, or a portion of, the identified parcels according to the objectives of and conditions of each strategy.

Parcels were included or excluded from a strategy depending on the focus and considerations for each strategy (discussed in Chapters 4–7). The riparian vegetation and wildlife focus of Strategy 1 was to compensate for the restrictions of existing flow capacity (and thus the lower area that could potentially be naturally recruited) by emphasizing horticultural restoration within the floodway. In addition, because Strategy 1 emphasizes anadromous salmonid rearing in Reach 1, the recommendations for riparian/wildlife strategies are focused on maximizing the number of appropriate sites for floodplain rearing (i.e., a larger number of appropriate sites were identified for floodplain rearing habitat than for other vegetation types). Under Strategy 1, parcels were included for horticultural restoration if they would provide larger habitat patches at strategic locations, such as at meander bends, connected by enhanced riparian buffers.

Because of the larger flow capacity and resultant increase in potential natural recruitment, the focus of Strategy 2 was to improve the riparian corridor for anadromous salmonids by enhancing SRA cover and increasing rearing habitat throughout the project area (i.e., not just focused in Reach 1). Under Strategy 2, parcels were included for horticultural restoration if they enhanced the riparian buffer width outside of the area predicted for natural recruitment, but typically still within the existing or proposed levee configuration.

Again, the larger flow capacity under Strategy 3 and the emphasis on riparian and wildlife needs focused the strategy toward improving the diversity of vegetation types throughout the project area and promoting increased wildlife benefits from larger habitat patches, wider riparian buffers, and increased habitat connectivity between the mainstem and adjacent natural areas (e.g., sloughs, tributaries, refuges). Although horticultural restoration of lands to improve habitat connectivity acreage was included under all strategies, it was expanded under Strategy 3.

3.5.4.5 Landscape-level linkages and riparian habitat connectivity

A primary component of the restoration target for the San Joaquin River corridor is the restoration of relatively wide riparian buffers. Riparian buffers are corridors of riparian vegetation that separate the river channel from adjacent managed lands. Typically, riparian buffers are discussed in the context of minimizing the effects of human land use activities on river-riparian ecosystems. Depending on their width, floristic composition, vegetative structure, and location within the larger landscape, riparian buffers can perform many important functions in the river system (Gregory et al. 1991, Mitsch and Gosselink 1993, Malanson 1993, Naiman and Decamps 1997, NRCS 1991), including:

- trapping and uptake of sediment from run-off and flood flows;
- stabilizing streambanks and reducing erosion;
- trapping and removing contaminants;
- providing shade and cover in near-bank aquatic habitats, to benefit a variety of native aquatic species;
- contributing large wood to the channel (when trees or branches fall into the river), which provide cover and habitat complexity for fish, amphibians, and turtles;
- contributing to riverine and terrestrial foodwebs;
- providing dispersal corridors for aquatic invertebrates and a variety of terrestrial plants and animals;
- providing nesting, rearing, foraging, and breeding habitat for native terrestrial species, particularly Neotropical migrant birds and bats;
- providing wildlife movement corridors, and
- creating scenic landscapes (aesthetic value).

In some sections of the study area, riparian vegetation may be naturally restricted to very narrow buffer zones. Management and restoration strategies need to consider the historical condition and the potential of a site to support appropriate riparian vegetation in the future. In some cases, existing infrastructure, land uses, or habitat characteristics (soils, topography, etc.) may limit the riparian buffer width. In these cases, even limited native riparian and floodplain vegetation should be encouraged to provide some cover for species living in or moving through the corridor. Wherever possible, however, buffer widths should be increased to at least 300 ft (100 m). Riparian buffers of these widths, or greater when possible, provide landscape-level habitat corridors, conserve riparian ecosystems and food webs, improve flood storage, and provide habitat for riparian forest-obligate wildlife species, such as yellow-billed cuckoo (Gaines 1974, Laymon et al. 1997).

One of the main goals of creating riparian buffers is to increase and maintain landscape-scale connectivity among patches of woody riparian vegetation along the San Joaquin River corridor. This includes enhancing both longitudinal connectivity along the river channel as well as lateral connectivity between the riparian corridor and upland habitat patches. This habitat connectivity can provide linkages among ecologically important areas for the various life-history stages of wildlife species found within the study area, and can create opportunities for genetic exchange between populations of organisms. Below we describe existing patches and complexes of protected habitat along the San Joaquin River corridor that could be used as starting points for enhancing existing areas and building larger networks of wildlife habitat. The habitat patches, presented from upstream to downstream (beginning at Friant Dam) within the project area, represent opportunities for habitat enhancement, restoration, and preservation, using a variety of implementation methods described in previous sections (e.g., easements, horticultural restoration).

The confluence of Little Dry Creek with the San Joaquin River (RM 260.5) and Rank Island (RM 260) is currently under public ownership and may provide a core area around which to focus initial conservation and restoration efforts in Reach 1. Great blue heron and egret rookeries occur on Rank Island (J. Cain, pers. comm., 2002), and numerous waterfowl and riparian bird species are found in the existing network of channels and standing water and marshy habitat at the mouth of Little Dry Creek (JSA 2001). Sycamore alluvial woodland habitat, a declining and relatively rare native vegetation type in California, is found about 5 miles upstream along Little Dry Creek, and provides particularly valuable habitat for larger hawks, such as Swainson’s hawks. Expanding the quality and/or quantity of wildlife habitat in this area would provide a protected node of diverse habitat types in Reach 1.

Kerman Ecological Reserve occurs just south of the San Joaquin River (the northern border of the Preserve is approximately 1.25 miles south of the river corridor) in Reach 2 (RM 223) (see Figure 2-1). It is managed by CDFG and is home to many sensitive species, including Lost Hills crownscale, lesser saltscale, and, at least historically, the Fresno kangaroo rat. The Alkali Sink Reserve and Mendota State Wildlife Refuge are located approximately 4 miles to the south of the San Joaquin River at RM 210 (Reach 2B). The Alkali Sink Ecological Reserve is home to many sensitive species, including blunt-nosed leopard lizard, Fresno kangaroo rat, palmate-bracted bird's beak, and Hoover’s woolly star. The Mendota State Wildlife Refuge includes the Fresno Slough area, and is home to numerous waterfowl and wading birds. Acquiring lands, or placing some of those lands under conservation easement, between the San Joaquin River and these three reserves would connect the main river corridor with these important core areas of wildlife habitat, which are otherwise tending to function primarily as “islands” within the larger landscape.

The area around the Bifurcation Structure (RM 216.1) and the Chowchilla Bypass (27 miles paralleling the San Joaquin River from RM 216.1 to 168), located in Reach 2, also represent opportunities for providing habitat linkages for wildlife species. The area around the Bifurcation Structure is the confluence of two major waterways, and should be considered as a node for establishing wildlife movement corridors. The Bifurcation area historically supported Fresno kangaroo rats and is home to other small mammal species. Increasing vegetation in this area would enhance habitat for birds and other wildlife, and would provide a corridor for animals traveling between the San Joaquin River, the Chowchilla Bypass, Mendota State Wildlife Refuge, and the Alkali Sink Ecological Reserve.

The Chowchilla Bypass remains dry for much of the year. However, when it is wet, only a thin margin of vegetation is present along the sides of the canal. A larger band of vegetation could provide additional cover for animals. The Chowchilla Bypass corridor is home to Fresno kangaroo rats and is used as a movement corridor for San Joaquin kit fox (Kucera et al. 2001). The Recovery Plan for Upland Species of the San Joaquin Valley identifies the Chowchilla Canal as one of its top priority restoration areas in the basin, particularly for San Joaquin kit fox and blunt-nosed leopard lizard. In addition to supporting mammals such as kit fox and kangaroo rat, a wider band of vegetation would provide habitat for birds, and provide a corridor for species traveling from the smaller rivers and creeks (Chowchilla River, Ash Slough) that drain into the Bypass before intersecting with the San Joaquin. Operation of the Bypass for flood control purposes, however, may severely constrain opportunities for establishing large amounts of woody riparian vegetation within the Bypass floodway.

Another opportunity to restore and enhance habitat for wildlife species is around Mendota Pool (border of Reaches 2B and 3). Mendota Pool currently provides lacustrine, marsh, and riparian habitat for a number of wildlife species. Focal species that historically occurred in this area include western pond turtle, yellow-billed cuckoo, and San Joaquin pocket mouse (CNDDB 2002). By actively managing Mendota Pool, enhancing the riparian buffer around its perimeter, and possible developing wetland complexes adjacent to the pool, we could further enhance the suitability of habitat for wildlife and native resident fish species.

The Merced River enters the San Joaquin River from the east at RM 118. Remnant riparian forests occur in this area and provide some of the largest and most contiguous patches of riparian habitat in the vicinity. The riparian corridor in this zone ranges from one-half to one mile wide and is bordered by protected state and private lands, row crops, dairies, and grazing lands. The area supports cottonwood forest, mixed riparian forest, mixed willow, valley oak forest, and herbaceous cover. This area is largely protected and includes George Hatfield State Park (along the Merced River), the China Island Unit of the North Grasslands Wildlife Area (managed by CDFG), and 335 acres protected by Stevinson Corporation conservation easements. Preservation of additional areas would provide connectivity with existing refuges and managed properties, enhancing the habitat value of this region. Much of Kesterson National Wildlife Refuge is a mosaic of wetland marsh complexes, and these habitats could be extended to include areas near the confluence of the Merced River. Given the large extent of intact riparian habitat, this area is likely to support a wide variety of wildlife species that would benefit from habitat preservation and active restoration projects. Many threatened, endangered, or sensitive species have been recorded in the vicinity of the Merced/San Joaquin confluence, including Delta button-celery, California tiger salamander, western spadefoot toad, giant garter snake, great blue heron, great egret, Swainson's hawk, tricolored blackbird, and San Joaquin kit fox (CDFG 2001).

3.5.4.6 Management of non-native invasive plant species

The San Joaquin riparian corridor, like most California landscapes, is host to many non-native invasive plant species. In 2000, the California Department of Water Resources (CDWR) mapped vegetation along the San Joaquin River from Friant Dam to the confluence with the Merced River (CDWR 2002). Their mapping identified 127 non-native plant species, or 50 percent of all plant species identified. The primary non-native invasive species identified in the CDWR mapping include: tree-of-heaven, giant reed, pampas grass, eucalyptus, edible fig, white mulberry, Lombardy poplar, castor bean, Himalayan blackberry, scarlet wisteria, and tamarisk (CDWR 2002). The CDWR effort also recorded parrot's feather, a highly invasive aquatic plant. Non-native invasive plant species cover 99 acres along the river corridor in nearly monospecific stands and occur as a component of most, if not all, native vegetation types (Chapter 8 in McBain and Trush 2002). These plant species are particularly abundant in Reach 1, where high levels of disturbance may have aided their spread, as suggested by their distribution in and around aggregate mining pits (McBain and Trush 2002).

Through funding by the San Joaquin River Riparian Habitat Restoration Program and based on the 2000 CDWR vegetation maps, the San Joaquin River Parkway and Conservation Trust prioritized non-native species for control as part of their current non-native invasive plant species management efforts for Reaches 1 through 5. Based on each plant's listing with California Exotic Pest Plant Council (CalEPPC), proximity to the active channel, potential for floodway impedance, relative ease of control, and relative cost of removal, the Parkway Trust identified the following species for high-priority control: scarlet wisteria, tree-of-heaven, giant reed, pampas grass, tamarisk, edible fig, and Himalayan blackberry. These species, as well as non-native annual grasses, parrot's feather, and water hyacinth, are discussed in detail in Appendix G-1, because they are documented as aggressive invaders that displace native plants and disrupt natural habitats (CalEPPC 1999). The location and extent of thee species within the planning area is summarized in Table 3.5-2.

Table 3.5-2. Location and extent of non-native invasive plant species within the planning area.

Species	Reach in which species were observed*
scarlet wisteria	Primarily Reach 1A, but found down to RM 242 in Reach 1B.
tree-of-heaven	3 acres in Reach 1A and 0.5 acres each in Reach 1B and Reach 2.
giant reed	Most abundant (~41 acres) in Reaches 1 and 2; ¼ acre or less in Reaches 3 and 5.
pampas grass	Not yet widespread, but documented in Reach 1.
tamarisk	Not yet widespread, although widespread in many tributaries to the San Joaquin.
edible fig	Documented in Reach 1.
Himalayan blackberry	Documented in Reach 1A, and likely to be established throughout the planning area, particularly in riparian scrub habitats that line the banks of the channelized river.
annual Mediterranean grasses	Not mapped by CDWR, but pervasive throughout the planning area.
parrot's feather	Documented in Reach 3; also observed near Lanes Bridge (RM 255.2) by Stillwater Sciences staff.
water hyacinth	Not mapped by CDWR, but observed by Stillwater Sciences staff in the lower reaches of the river. May have been more widespread prior to 1997 floods (S. Weaver, pers. comm., 2003).

*based on mapping conducted by CDWR (2002). See Appendix G-1 for more information.

Exotic plant species can alter the structure and dynamics of natural ecosystems. Non-native plant species can impact native wildlife by displacing native vegetation that is used for nesting or as a food source. Once established, non-native plant species can alter nutrient cycling, energy fixing, food web interactions, and fire and other disturbance regimes, to the extent that the native landscape is changed. Habitat fragmentation contributes to the spread of non-native species by increasing edge habitat, which provides greater opportunities for invasion by exotic species (Cox 1999). Ecosystem alterations resulting from non-native plant species invasions can be exacerbated by activities such as grazing and vegetation clearing that create favorable conditions for further non-native plant establishment (Cox 1999, Randall and Hoshovsky 2000). Alteration of historical flooding regimes by flow regulation further promotes invasions by non-native species by eliminating processes necessary for recruiting and maintaining native plant species (Cox 1999).

Typical eradication and control methods for non-native invasive plant species include mechanical removal (including by hand, or with tools, heavy machinery, etc.), chemical removal (herbicides), and in a few cases biological control. Other issues to consider in managing non-native invasive plants include:

- *Eradication of isolated occurrences of invasive non-native plants*. Eradicating non-native plant species is difficult and usually unattainable. Complete eradication is, however, a potentially feasible goal where non-native species occur as small, isolated patches. In the San Joaquin River corridor, pampas grass and tamarisk are two such species that, because of their isolated distribution and limited extent, could potentially be eradicated. Eradicating these types of species would likely require an integrated pest management approach (e.g., a combination of physical removal and limited herbicide application) to remove the existing stands, monitoring of sites to identify any resprouting of treated stands, maintenance to treat any resprouting, and river-wide monitoring to identify any other occurrences or recent introductions of the species (see below).
- *Minimizing the introduction of non-native plant species when implementing restoration actions*. Because many non-native species can out-compete native species in colonizing disturbed areas, non-native species can interfere with the success of restoration actions, particularly when restoration actions (such as dispersal flows, floodplain grading, or channel modifications) create opportunities for the dispersal and establishment of the invasive species. The biology of potential invasive species and the techniques available to control their spread should therefore be considered when developing restoration strategies and actions.
- *Promoting processes and conditions that encourage native plant species recruitment over non-native species*. Habitat fragmentation, alteration of historical disturbance regimes (such as flooding and fire), and increased nutrient delivery by adjacent land uses are just a few of the ways humans have altered riparian areas such that non-native plant species have a competitive advantage over natives. Conserving and expanding existing native habitat patches will not only reduce edge habitat (which is more easily colonized by non-native species), but will also provide necessary sources for native seed dispersal. Restoring natural fluvial processes to the extent possible will provide the conditions necessary to recruit native riparian species (such as bare, moist seedbeds and thinning of the understory), while scouring and inhibiting non-native species. Actions to improve water quality, such as the ongiong TMDL process, will also help improve conditions for natives that are sensitive to elevated levels of nutrients and other pollutants.
- *Re-establishing native plants in areas where non-native species are removed or treated*. Removal of invasive species is not guaranteed to remove the invasive impacts. Locally extirpated native species may require re-introduction to the site.
- *Establishing a river-wide monitoring program*. Frequent monitoring of the river corridor will be needed to identify recent introductions and infestations. Once a species has become widespread and abundant, mechanical and/or chemical removal can be prohibitively expensive, and even after an invasive species is removed, it frequently re-invades, requiring ongoing treatment. Regular monitoring of the river corridor for new introductions or resprouting of treated stands will help identify small, isolated patches of invasive non-native plants that can be more feasibly eradicated before they become widespread.

3.5.5 Restoration targets for specific vegetation and habitat types

Section 3.5.4.5 identified geographical areas that may provide site-specific opportunities for increasing riparian buffers and habitat connectivity within the project area. Riparian buffers and core areas of wildlife habitat can be composed of a diversity of specific vegetation and habitat types. This section describes restoration targets for these vegetation types or natural communities, and discusses associated wildlife benefits that would result from restoration of the following:

- riparian forest and scrub,
- valley oak woodland,
- freshwater marsh and wetlands,
- alkali scrub and wetlands,
- elderberry savanna,
- Central California sycamore alluvial woodland, and
- vernal pools.

For each natural community type, we discuss (1) the common or dominant vegetation and distribution of the community, (2) the habitat value provided by the native vegetation in the community, and (3) the restoration target for the community. These targets should be used as preliminary guidelines to be considered in developing the SJR restoration plan. The targets are intended to feed into a stakeholder-based process to develop a shared restoration vision for the 150-mile corridor.

A broad diversity of wildlife species along the San Joaquin River corridor, representing numerous ecological niches and habitat requirements, depend on these natural plant communities. In order to develop riparian objectives (see Restoration Objectives Report) and to evaluate the benefits of potential restoration actions, we selected a group of species (analysis species) that currently occur or historically occurred within the San Joaquin corridor. These species were selected based on their status under state and federal Endangered Species Acts, the prevalence of preferred habitat within the project area, and the ecological niche they represent. These analysis species cover a range of habitat and vegetation requirements and represent various taxonomic groups and guilds within the river-riparian ecosystem. Technical information on each analysis species (presented in the Restoration Objectives Report) was used to help develop vegetation objectives and to identify the potential restoration targets and opportunities described below for each natural community.

3.5.5.1 Riparian forest and scrub

Description and distribution

Riparian forest is a multi-layered native vegetation type that was once widespread throughout the Central Valley. Riparian forest and scrub is generally found on the low active floodplain of the San Joaquin River and adjacent low or intermediate terraces.

Under pre-dam conditions, riparian forest included cottonwood riparian forest, mixed riparian forest, and valley oak riparian forest vegetation types, with mixed riparian forest intergrading with valley oak riparian forest at sites higher on the floodplain, and with cottonwood riparian forest and willow scrub on sites closer to the active channel. Flood flow attenuation following the construction of Friant Dam has, however, altered the toposequence of riparian forest types and mixed riparian forest now often occurs at elevations where cottonwood riparian forest historically occurred (McBain and Trush 2002). Species dominance in riparian forest depends on site conditions, such as elevation, availability of groundwater, and frequency of flooding. Dominant tree species in the riparian forest vegetation type generally include Fremont cottonwood, Gooding’s black willow, box elder, Oregon ash, and western Sycamore. White alder occurs immediately along the water’s edge in the upper portion of the study area. Common shrub species are red willow, arroyo willow, buttonbush, California wild grape, and California wild rose. The ground layer varies from sparse to lush with a mixture of native and non-native grasses and forbs.

Riparian scrub is a dense assemblage of willow and other shrubs often found within the active floodplain of the river (McBain and Trush 2002). Sites with riparian scrub are subject to more frequent scouring flows than are sites supporting riparian forests. Riparian scrub often occupies stable sand and gravel point bars immediately above the active channel. Often, riparian scrub is successional to riparian forest and persists only in the presence of frequent disturbance. Dominant shrubs include narrowleaf willow, arroyo willow, and red willow. Occasional emergent Fremont cottonwood may also be present in willow riparian scrub. Several invasive exotics (giant reed, Himalayan blackberry, and scarlet wisteria) are more abundant in riparian scrub than in other vegetation types (McBain and Trush 2002).

Riparian forest and scrub are found in all reaches of the river, with the majority occurring in Reaches 1 and 5 (CDWR 2002). Historically, Reach 1 and potentially portions of Reach 2 consisted of bands of riparian forest and scrub along the floodway of the river corridor, typically in discontinuous patches along high flow scour channels and side channels closer to the groundwater table (McBain and Trush 2002). Reaches 2 through 5 consisted of bands (typically less than 2,000 feet wide) of woody riparian vegetation (in places perhaps exclusively black willow) along the margins of the river channels and sloughs, with extensive tule marshes in the flood basins beyond the relatively narrow riparian bands. In these reaches, riparian forest and scrub probably also grew on higher ground along the margins of sloughs, oxbow lakes, and minor natural levees along abandoned channels (McBain and Trush 2002).

In comparison with historical conditions, existing bands of riparian forest and scrub are very narrow, in some instances only one-tree wide, and patches are small and isolated by adjacent land uses. A lack of scouring flows and bed mobility resulting from flow regulation has allowed riparian vegetation to become established on formerly active gravel bars in several reaches. This encroachment of pioneer riparian species (primarily narrowleaf willow) into the active channel, particularly in Reach 1, has reduced the active channel width, simplified the channel cross section, and reduced aquatic habitat. Riparian forest and scrub distribution, composition, and health have been impacted by clearing of floodplain areas for agriculture and reduced natural recruitment as a result of changes in flow and sediment supply from flow regulation. In addition, numerous non-native, invasive plant species have become established within the riparian corridor and can compromise the quality of riparian forest and scrub habitats.

Habitat value

Lush riparian forests and scrub that border the river channel and perform the functions listed are often referred to as shaded riverine aquatic (SRA) habitat. Increasing and enhancing SRA habitat to improve shade, cover, and food for chinook salmon and steelhead is listed as a programmatic restoration action for both the west and east San Joaquin Basin Ecological Management Zones by the CALFED Bay-Delta Program (CALFED 2000).

In California, over 225 species of birds, mammals, reptiles, and amphibians depend on riparian habitats, and riparian ecosystems harbor the most diverse bird communities in the arid and semi-arid regions of the western United States (Knopf et al. 1988, Dobkin 1994, Saab et al. 1995). In addition to high species richness, riparian areas can harbor individuals during the bird breeding season (May–June) at densities up to ten times greater than the surrounding terrestrial habitats (RHJV 2000). The discussion below summarizes the value of riparian forest and scrub for western pond turtle, yellow-billed cuckoo, riparian brush rabbit, and bats. The habitat requirements of these species help define minimum patch size and acreage goals for the preservation and restoration of riparian forest and scrub within the project area.

Deciduous riparian forest habitats adjacent to backchannels, side channels, ponds, and rivers are important habitat types for western pond turtle (Nussbaum et al. 1983, Zeiner et al. 1988). Western pond turtles use riparian forest habitat for burrowing and nesting, and also for basking, particularly along backwater channels. Juxtaposition of suitable aquatic foraging and basking sites with riparian or upland burrowing and nesting sites is a key determinant of habitat quality for this analysis species. Because habitat use can vary greatly among turtle populations, and because turtles often return to the same wintering and nesting sites each year, Reese (1996) suggests that management priorities should be site- and population-specific. Reese's recommendations include establishing a buffer zone on each side of the watercourse of at least 1,650 ft (500 m) for key sites.

Yellow-billed cuckoo is an example of a riparian-obligate species and is found only in larger patches of willow-cottonwood riparian forest vegetation types. Cuckoos inhabit densely foliated, deciduous trees and shrubs, particularly willows, with a dense understory formed by blackberry, nettles, and/or wild grapes adjacent to slow-moving watercourses, backwaters, or seeps (CDFG 1983). Field studies and habitat suitability modeling have concluded that vegetation type (e.g., cottonwood-willow), patch size, patch width, and distance to water are critical factors determining the suitability of habitat for yellow-billed cuckoo breeding (Laymon and Halterman 1989, Greco 1999). Patch size was the most important variable determining presence of cuckoos on the Sacramento River from 1987 to 1990 (Halterman 1991, as cited in Laymon 1998), with a trend toward increasing occupancy with increased patch size. Willow-cottonwood habitat patches greater than 600 m in width were found to be optimal, while typically anything less than 100 m was unsuitable (Laymon and Halterman 1989). Halterman (1991, as cited in Greco 1999) and Laymon et al. (1997, as cited in Greco 1999) also observed nesting more frequently in areas where the distance to water was less than 100 m. Dense vegetation less than 20 m in height is especially important for nesting, while lower and higher vegetation with greater overall foliage density is used for foraging (Laymon et al. 1997, as cited in Greco 1999). Young, rapidly growing stands of riparian vegetation provide preferred nest sites and high productivity of invertebrate prey, with a lower prevalence of predators compared with older stands (Laymon 1998; Halterman 1991, as cited in Laymon 1998). Greco (1999) defined this to be less than 45–60 years since vegetation became established on newly formed substrate, stressing the importance of meandering riparian systems with intact erosional and depositional processes that create new areas for riparian vegetation to establish. Halterman (1991, as cited by Laymon 1998) found that habitat fragmentation, as determined by the extent of habitat per 8-km river reach, was the second most important variable (after patch size) in determining the presence of cuckoos, followed by the presence of low woody vegetation. Conservation and restoration efforts need to keep in mind that large areas need to be conserved to allow for the natural formation and loss of yellow-billed cuckoo habitat. Management strategies involving "minimum dynamic areas" (Pickett and Thompson 1978, as cited in Greco 1999), such as those discussed in the Sacramento River Conservation Area Handbook (California Resources Agency 1998, as cited in Greco 1999), are preferred over conservation of minimum patch size areas (Greco 1999). Restoration should be geared toward maintenance of channel hydrodynamic processes that result in formation of complex riparian habitat (Greco 1999). The Restoration Objectives Report describes yellow-billed cuckoo life history, distribution, habitat requirements, and restoration goals in detail.

Riparian brush rabbits are most often found in clearings within dense riparian forests within the natural floodplain, feeding on understory vegetation (Williams 1986). The riparian brush rabbit has been heavily impacted by construction of large dams in the Central Valley and the conversion of large tracts of land to agriculture, which has fragmented riparian habitat. It is considered one of the most sensitive mammals in California because of its susceptibility to floods, fire, disease, predation, disturbance, and flood control activities (CALFED 1997). This species is not known to disperse far and has a relatively small home range. Riparian brush rabbits will not cross large open areas, so habitat connectivity is important for this species. Because of their small home range, smaller patches of suitable habitat may be sufficient for individual rabbits or pairs, but a complex of adjoining patches is needed to maintain populations of this species by connecting tracts of suitable habitat and upland areas in order to provide cover from annual floods (CALFED 1997).

Bats account for a substantial fraction of the native mammal diversity within the Central Valley. All species found in California are insectivorous and foraging by many bat species is concentrated near rivers, streams, and riparian vegetation. Foraging strategies and nightly movement distances differ among species, but range from a fraction of a kilometer to several tens of kilometers per night. During the day, bats roost in foliage or in crevices and cavities, presumably in larger trees, or snags in mature riparian forest remnants. Persistence (or restoration) of local bat diversity is intimately tied to riparian forest dynamics. Existing evidence indicates that cottonwood and sycamore riparian forests provide high-quality roosting habitat for several bat species, such as western red bat and California myotis (Barbour and Davis 1969, Pierson et al. 1999), as well as potentially critical foraging habitat for big brown bat, western red bat, and hoary bat (E. Pierson, pers. comm., 2002). A recent study suggests that riparian restoration projects that reinstate naturalistic flood regimes and foster regeneration of cottonwood and sycamore would benefit the western red bat (E. Pierson, pers. comm., 2002).

Habitat restoration target

Restoration goals for improving the quality and quantity of riparian forest and scrub in the San Joaquin River corridor were developed by: (1) identifying current patches of the vegetation type suitable for conservation and enhancement; (2) identifying areas along the river that have physical, chemical, and inundation characteristics suitable for supporting riparian forest and scrub; (3) extracting conservation recommendations from the scientific literature regarding habitat requirements for wildlife analysis species; and (4) following the recommendations given in the Riparian Habitat Joint Venture's Riparian Bird Conservation Plan (RHJV 2000). A wide variety of research and literature strongly supports the value of healthy riparian forest and scrub in maintaining many of the functions of the river-riparian ecosystem and providing habitat value for fish and wildlife. Goals for restoration of riparian forest and scrub include:

- Increasing the acreage of the riparian forest and scrub throughout the river corridor. Riparian habitat patches should be of sufficient size to support riparian-dependent species. The quantitative data available on patch size requirements of yellow-billed cuckoo provide a starting point for establishing minimum habitat patch sizes for protection or restoration. Riparian forest habitat patches between 100 and 600 m (or greater) in width have been documented to support yellow-billed cuckoo (Laymon and Halterman 1989), and will support a wide variety of other riparian-dependent species. As more quantitative data become available, minimum and ideal patch sizes can be refined for the management of other riparian wildlife populations. At a minimum, a riparian corridor width sufficient to support chemical, physical, and habitat functions important to the river system should be restored. A range of corridor widths can be prescribed to achieve specific restoration goals or support particular wildlife species. For example, a buffer zone of at least 1,650 ft (500 m) has been recommended to support western pond turtle populations (Reese 1996). Section 3.3.7 in the Restoration Objectives Report (Stillwater Sciences 2003) summarizes other buffer widths that have been proposed in the literature to protect various ecosystem functions in different regions.
- Restore and maintain riparian forest and scrub, in large contiguous patches (where possible) that include a mosaic of different successional or structural stages of woody riparian vegetation and other native vegetation types. Connectivity between habitat patches is particularly important to riparian brush rabbit, which will not cross open areas, and yellow-billed cuckoo, which require large tracts of intact riparian habitat. Expanding and linking

isolated patches of habitat provides dispersal corridors for plant and animal populations and movement corridors for access to various habitat types along the river corridor.

- Utilize natural fluvial geomorphic processes as much as possible to maintain a self-sustaining system of riparian forest and scrub. A governing assumption of all three restoration strategies is that managing flows to promote natural revegetation processes is the most effective and efficient means of restoring riparian forest and scrub throughout the 150-mile San Joaquin River corridor. Restoring flows that provide periodic scour, inundation, or sediment deposition will also help reduce the threat of riparian encroachment into the river channel.

According to the vegetation mapping conducted by CDWR (2002), the GIS analysis conducted by Stillwater Sciences, and the results of the Stillwater Riparian Recruitment Model, there are approximately 6,000 acres of existing riparian forest and scrub that are suitable for conservation or enhancement and potentially another 6,000 acres along the river corridor that have the soil, elevation, and potential for inundation required to support the restoration of riparian forest and scrub. Reaches 1A, 4B2, and 5 have the greatest potential area (approximately 1,000 to 2,000 acres each) suitable for the restoration and conservation of riparian forest and scrub, although the other reaches have substantial potential as well.

Riparian forest and scrub should be maintained, enhanced, or restored through a combination of preservation of existing patches, flow management to promote natural recruitment and disturbance processes, and active restoration (such as horticultural revegetation techniques or floodplain reconstruction to increase floodplain connectivity, and facilitate natural regeneration processes). Natural fluvial geomorphic processes should be utilized as much as possible to maintain a self-sustaining system of riparian forest and scrub, but management intervention should be considered to speed up development of the desired condition or to maintain it in locations where a process-based approach would not be effective. In Reaches 4 and 5, the potential area for riparian recruitment is substantially greater than the extent of existing riparian vegetation. In these areas, the objective of flow management should be to maintain or enhance existing stands and to restore additional acreage of riparian forest and scrub. Uncertainty exists, however, as to whether prolonged inundation or levels of boron and selenium in soil and water in Reaches 4 and 5 will limit potential restoration of woody riparian vegetation to substantially less acreage than that predicted by the San Joaquin River Riparian Recruitment Model.

3.5.5.2 Valley oak woodland

Description and distribution

Valley oak woodland is a native vegetation type in California's Central Valley. It is a vegetation type of special concern because of its declining distribution throughout the state, severe reduction in extent compared with historical times, and the disruption/suppression of its regeneration processes (IHRMP 1996). Valley oak woodland typically consists of an overstory canopy dominated by valley oak and an understory dominated by grasses and annual forbs. Associated tree species include western sycamore, California black walnut, box elder, Oregon ash, interior live oak, California buckeye, and blue oak. This vegetation type typically occurs on the highest parts of the floodplain and on terraces, where it is less subject to physical disturbance but still receives annual subsurface irrigation and periodic inputs of silty alluvium during larger flood events. The valley oak forest canopy averages 50–65 ft in height, and mature dominant trees can reach 120 ft tall (IHRMP 1996). Canopy closure in valley oak forest type varies from open (representing a savanna or woodland phase) to dense (true forest, typically occurring in riparian zones). Dense-canopy valley oak riparian forest, which occurs in lower, wetter areas in the riparian zone, is included in the riparian forest and scrub discussion above.

Historical records suggest that valley oak woodland did not occur in Reaches 2 through 5 of the project area and was limited to terraces in Reach 1 by confining bluffs although there is still much uncertainty over the actual historical distribution of this vegetation type (McBain and Trush 2002). Clearing for agriculture and livestock grazing has dramatically reduced the extent of this habitat type. In addition, valley oak regeneration is not sufficient to replace mature trees lost to natural and human causes. Likely causes of reduced regeneration include competition for surface water with non-native grasses and forbs, acorn and seedling predation by livestock, deer, and small mammals, and alteration of the natural flooding regime. In upland areas, fire suppression has limited valley oak recruitment by encouraging competition from drought-tolerant understory plants (IHRMP 1996, Pavlick et al. 1991). Currently, there are about 265 acres of valley oak woodland in Reach 1A and smaller patches in Reach 4B1 (16 acres), Reach 4B2 (7 acres), and Reach 5 (46 acres) (McBain and Trush 2002, Stillwater Sciences 2003).

Habitat value

Valley oaks and other trees, shrubs, and grasses associated with oak woodlands provide habitat structure and foraging opportunities for a diverse assemblage of native wildlife, including many that are associated with the river corridor. In turn, the species that depend on oak woodlands for foraging, breeding, and cover influence the structure and composition of the oak woodlands through herbivory, seed dispersal, nest building, and other activities. Oak acorns, leaves, twigs, sap, roots, and pollen are all important wildlife food sources. Martin et al. (1951) list 19 species of bird and 11 game, small, or hoofed mammal species occurring in the Pacific region (California, Oregon, and Washington) that rely on acorns or oak twigs and foliage for an appreciable portion of their diet. Nine of these species consume acorns for 25–50 percent of their diet (Martin et al. 1951). The cavities, perches, and cover found in valley oak woodlands provide habitat for a variety of wildlife species. More than 300 vertebrate species have been documented to use oak-dominated woodlands for breeding, foraging, or cover (Block et al. 1990, Pavlick et al. 1991). The discussion below summarizes the value of valley oak woodlands for Swainson's hawk and acorn woodpecker. These bird species use valley oak woodlands for part or all of their life history and their habitat requirements help define minimum patch size and acreage goals for the preservation and restoration of valley oak woodland.

Although the availability of nesting substrate is closely tied to riparian areas, Swainson's hawk is not an obligate-riparian species (Bloom 1980, Estep 1989). Swainson's hawks are known to nest in isolated oak woodland bordering narrow bands of riparian vegetation (England et al. 1997). The proximity of a nest site to foraging areas (e.g., where suitable prey are open to aerial attack, such as agricultural fields under moderate levels of cultivation) is an important factor determining habitat suitability. A trend toward planting crops unsuitable for Swainson's hawk foraging and urban expansion into agricultural and grassland areas represent the major threats to this species' breeding grounds (CDFG 1992). Restoration recommendations for Swainson's hawk emphasize the continued need for available, suitable nesting and foraging habitat through preservation of riparian systems, woodlands, and lone groves or mature trees in agricultural fields (CDFG 1992). Tree planting is a preferred management technique where nest sites (large, old trees) are limiting (England et al. 1997). Bloom (1980) believed that the Central Valley Swainson's hawk population, because of its size and distribution, could function as a center for the dispersal of populations for the colonization of historically occupied sites. CDFG (1994) recommends an average of 15,000 acres of potential foraging area per nesting pair should be preserved in order to avoid jeopardizing the existing population. The area preserved should also be sufficient to accommodate additional hawks to successfully breed and utilize foraging habitat during good production years (CDFG 1994).

Acorn woodpeckers prefer pine-oak woodlands where oaks are plentiful. They are commonly found in oak woodland habitats growing adjacent to riparian sycamore groves (Small 1994). They prefer stands with snags and sparse canopies (Zeiner et al. 1990). Although acorn woodpeckers typically feed on insects, sap, oak catkins, fruit, and flower nectar, acorns constitute over 50 percent of the acorn woodpecker diet (Pavlick et al. 1991). Acorns are stored in individually-drilled holes in dead limbs or thick bark of a granary tree. Acorn woodpeckers typically forage in or near the canopy of oak woodland habitats, and require water daily (Zeiner et al. 1990). Curtis (1981, as cited in Zeiner et al. 1990) described optimal habitat as an open oak forest patch of at least 15 ac (6 ha), containing at least 4 species of oak, and less than 0.4 km (0.25 mi) from water. Acorn woodpeckers typically live in communal groups of 2 to 16 individuals, defending a territory of 1–7 trees 11.5 acres (4.7 ha) (Swearingen 1977, as cited in Zeiner et al. 1990). Continued elimination of oaks in California due to development and disease is a threat to this species (Verner and Boss 1980, as cited in Zeiner et al. 1990).

Habitat restoration target

The following restoration goals for valley oak woodland in the San Joaquin River corridor were developed and prioritized by: (1) identifying current patches of the vegetation type suitable for conservation and enhancement; (2) identifying areas along the river that have physical and chemical characteristics suitable for supporting oak valley woodland (using a GIS analysis of the DEM assessment area); (3) using information on habitat requirements for the analysis species described above; and adapting published guidelines for oak woodland restoration and conservation (CalPIF 2002).

- Expand existing patch of oak woodland in Reach 1A. Review of existing soil and topographic characteristics of the existing patches of valley oak woodland indicates that there are up to 500 acres in Reach 1A potentially suitable to support oak woodland restoration. Expanding existing patches of valley oak woodland would provide an important center for the dispersal of valley oak, associated plant species, and wildlife populations. Increasing the extent of existing patches would provide valuable breeding, and cover habitat for wildlife such as Swainson’s hawk, and could potentially provide a link between isolated patches of habitat in the area, improving conditions for the movement of wildlife throughout the river corridor.
- Create patches of valley oak woodland in Reach 3. Review of soil and topographic characteristics of this reach indicate that there are potentially many acres in Reach 3 suitable to support valley oak woodland (e.g., elevation of 8–16 feet above the water table; unstratified non-saline soils with coarse or medium texture; and current non-native vegetation land cover in the disturbed, herbaceous, or agricultural categories). Creating relatively large patches (e.g., 20–40 acres or larger) should be explored in this reach, in order to increase the wildlife habitat value of restored sites, although restoration sites may be smaller (e.g., 10 acres) and still retain much habitat value if they are adjacent to intact riparian forest stands.
- Link and expand the small, isolated patches of valley oak woodland in Reaches 4B1, 4B2, and 5. Reach 5 at the confluence of the Merced River is currently the focus of several extensive conservation efforts by the Stevinson Corporation to protect the existing stands of high-quality riparian and oak forest in this area. Linking and expanding the isolated patches in these lower reaches would enhance the on-going conservation efforts at the confluence of the Merced River and extend the area and wildlife habitat value of neighboring easements and wildlife refuges.

According to the vegetation mapping conducting by CDWR (2002), the GIS analysis conducted by Stillwater Sciences, and the results of the Stillwater Riparian Recruitment Model, there are approximately 300 acres of valley oak woodland that are suitable for conservation or enhancement and potentially 3,000 acres along the river corridor that may have the soil and relative elevation characteristics (as a proxy for depth to groundwater) required to support horticultural restoration of valley oak woodland. Griggs and Golet (2002) document successful horticultural restoration of valley oaks along the Sacramento River when suitable soils and elevation to groundwater conditions were present.

The restoration of valley oak woodland along the San Joaquin River will likely require a combination of preserving existing patches as a source of acorn dispersal for natural regeneration and recolonization, and horticultural restoration to expedite recolonization of oaks, as natural recruitment of valley oaks, especially in open woodlands and savannas, is low or nonexistent in much of California (Pavlick et al. 1991). At some sites, such as the lower reaches where levee setbacks may be proposed, flow management and floodplain reconstruction may be used to create conditions that will support oak valley woodland.

3.5.5.3 Freshwater marsh and wetlands

Description and distribution

Freshwater marsh and wetlands encompass a diverse spectrum of habitats ranging from seasonally saturated or inundated to persistently inundated, with the type of vegetation reflecting the duration of saturation or inundation (NRC 1995, Middleton 1999, McBain and Trush 2002). Characteristic marsh species include bulrushes and cattails. The most abundant wetland herbaceous species in the project area are western goldenrod and pale smartweed (McBain and Trush 2002). Freshwater marshes can form in backwater channel areas, oxbow lakes and sloughs, and on floodplain terraces.

Vast areas of freshwater marsh complexes dominated by tules (hardstem bulrush), cattails, and other emergent wetland plants once dominated the flood basins bordering the San Joaquin River from Reach 3 through Reach 5 (see Chapter 8 of the Background Report). Of the 4 million acres of wetlands that existed in the Central Valley in the 1850s, a mere 14 percent (560,500 acres) remained in 1939 (Beedy and Hamilton 1997). Remnants of these freshwater wetland complexes are still found in the San Luis National Wildlife Refuge complex (see Appendix G-2) and at selected other locations along the river. At present, approximately 1,000 acres of wetlands occur in the project area, two-thirds of which occur in Reach 4 and 5 (see Restoration Objectives Report Table 3-2). Most of the remaining wetlands in the study area are associated with aggregate mining pits in Reach 1A.

Habitat value

Wetlands provide many ecological functions and values, including high productivity, nutrient cycling, and filtration (Middleton 1999, Mitsch and Gosselink 1986, NRC 1995). Large complexes of wetlands with habitats ranging along a toposequence from deep water (>6 feet deep), to submersed and floating aquatic macrophytes, to emergent tules and cattails, and then to seasonal wetlands along the margins provide valuable breeding, foraging, and cover habitat for a wide variety of avian species, reptiles, and amphibians. Waterfowl species such as mallards, green-winged teal, ring-necked ducks, and northern pintails are found on the San Luis National Wildlife Refuge complex (http://sanluis.fws.gov/sanluis_info.htm), and many species of resident and migratory shorebirds, wading birds, rails, and songbirds depend upon the seasonal and permanent wetland areas of the San Joaquin Valley. The discussion below summarizes the value of freshwater marsh and wetland for: waterfowl, giant garter snake, tricolored blackbird, and white-faced ibis, which depend on freshwater marsh for all or a significant portion of their life cycle. The habitat requirements of these species help define minimum patch size and acre goals for the preservation and restoration of freshwater marsh and wetland. They are summarized briefly below and discussed in more detail in the Restoration Objectives Report.

Waterfowl species depend on marsh habitats for foraging and cover. A number of waterfowl species, including northern pintail and mallard, commonly breed and overwinter in the San Joaquin Valley. They prefer open shallow-water feeding areas bordered by emergent vegetation where preferred cover types include bulrush, cattail, and tule (Weller 1994). Waterfowl species that breed in the San Joaquin Valley, such as the mallard, prefer to nest near foraging sites and usually nest within 100 m of water (Small 1994). Breeding waterfowl prefer to conceal nests in dense emergent stands of vegetation (Weller 1994).

Giant garter snakes depend on marsh habitats, particularly with mud and silt bottoms for foraging and cover. They require permanent marshes with emergent vegetation (such as tules and cattails) adjacent to low-growing bankside vegetation (such as blackberry or grape). Median home ranges have been estimated anywhere from 9 hectares (23 acres) to 53 hectares (131 acres) for this species. Foraging sites are typically within 50 m of water, while overwintering burrows (typically abandoned mammal burrows) can be as far as 250 m from water (Wylie et al. 1997). According to USFWS (1999), the San Joaquin Valley subpopulations have shown severe declines over the last 2 decades. The major cause for decline is attributed to loss of habitat from conversion of aquatic, wetland, riparian, and adjacent upland habitats to other land uses, and degradation of habitat from land-use practices (CALFED 1997).

Tricolored blackbirds require the following habitat characteristics for successful breeding: (1) open, accessible water at or near the breeding site, (2) protected nesting substrate, usually flooded by at least one foot (Hamilton, pers. comm.) and/or with spiny or thorny vegetation to protect nests from predators, and (3) suitable foraging grounds within a few (< 5) miles of the nesting colony (Beedy and Hamilton 1997). Tricolored blackbirds typically nest in tules and cattails but are also found nesting in silage and grain fields, Himalaya berries, *Arundo*, and tamarisk. A majority of colonies currently depend on privately owned agricultural fields for nesting (Miller and Hornaday 1999). Nesting colonies range in size from a minimum of 50 breeding pairs (Grinnell and Miller 1944, as cited in Zeiner et al. 1990a; T. Beedy, pers. comm.), to tens of thousands of birds (e.g., 30,000 birds reported in a colony on the Merced NWR; S. Milar, pers. comm. 2002). Hamilton (pers. comm.) suggests a restoration goal of 1,800 to 3,000 birds as a sustainable nesting colony. Minimum patch size required for breeding was estimated to be between 3 and 5 acres of suitable nesting substrate to account for habitat heterogeneity (Hamilton, pers. comm.; Beedy, pers. comm.). According to Beedy (pers. comm.), a colony would be unlikely to establish in an area less than one acre, unless nesting conditions were optimal (e.g., abundant available prey and protected nesting substrate like Himalaya blackberry).

Like tricolored blackbirds, white-faced ibis nest in tules and cattails. Some shallow water habitat is required for fledgling rearing. White-faced ibis forage in irrigated fields, pastures, open marshes, mudflats, canal edges, ponds, and ditches, typically in habitat patches of at least 30 hectares (74 acres), within 6 km of a colony site (Bray and Klebenow 1988). Earnst et al. (1998) suggest that ibis "would benefit from a landscape mosaic of well-distributed peripheral wetlands and persistent colony sites. The nomadic nature of the white-faced ibis and the dynamic nature of their breeding habitat necessitates that wetland management decisions and population monitoring be conducted in a regional context."

Wetland habitat values for native resident fish are discussed in Section 3.4.6.2.

Habitat restoration target

The following restoration goals for improving the quality and quantity of freshwater marsh and wetlands in the San Joaquin River corridor were developed and prioritized by: (1) identifying current patches of the vegetation type suitable for conservation and enhancement; (2) identifying areas along the river that have physical and chemical characteristics suitable for potentially supporting freshwater marsh and wetlands; (3) considering the historical vastness of this community type in the study area; and (4) following guidelines for freshwater marsh and wetland restoration and conservation focused on specific wildlife species described above.

- Maintain or enhance the existing patches of this ecologically valuable native vegetation type in the river corridor. In particular, identify opportunities to create larger marsh and wetland complexes in Reaches 2B–5, where remnant patches are concentrated. Such opportunities would be especially valuable if the additional restoration builds on existing wetlands, such as the managed wetlands on the San Luis NWR, to create freshwater marsh/wetland complexes greater than 100–200 acres in size. See Appendix G-2 for more specific information on wetlands management on the San Luis NWR complex.
- Incorporate freshwater marsh when opportunities for recontouring flood basin topography behind low riparian berms along the main channel arise. The proposed levee setbacks in Reach 2B and 4B1 to increase flood conveyance capacity should provide good opportunities for restoration of new wetland areas.
- Create mosaics of upland, seasonal wetlands and permanent, open water and emergent wetlands, including conservation of existing oxbow lakes and sloughs, to support a diversity of waterfowl, other avian species, reptiles, and amphibians. For example, management of wetlands should also consider needs of species like the giant garter snake, whose hydroperiod requirements are often opposite that of migratory waterfowl (see Restoration Objectives Report). A mosaic of freshwater marsh and wetlands on gradients of topography and in various successional stages will facilitate foraging, cover, and nesting habitat requirements for wildlife species discussed above.
- Consider prioritizing restoration efforts in areas identified in Recovery Plans as critical for special-status wildlife species that depend on freshwater marsh habitat. For example, the Draft Recovery Plan for the giant garter snake (USFWS 1999) highlights the following areas that are in or near the project area:
    1. North and South Grasslands area (Reaches 4 and 5): Parts of this area are privately owned and recommendations are to “develop and implement a management plan benefiting the giant garter snake, restore wetland habitat, create additional nesting habitat for the tri-colored blackbird, protect existing tri-colored blackbird breeding colonies, maintain compatible agricultural practices, and protect and maintain wintering habitat for the white-faced ibis.”
    2. Mendota Area (Reach 2B/3): This area is private and recommendations are to “develop and implement management plan benefiting the giant garter snake,” and “to restore wetland habitat.”
- Consider the susceptibility of these areas to predators. Predation by black-crowned night herons (a native wetland species) on tricolored blackbirds is considered one of the primary threats to this species.

Large freshwater marsh complexes were once a dominant habitat type in the flood basins of Reaches 3 through 5, but have been reduced to remnant patches, including those within the project area (approximately 1,000 acres) and the adjacent San Luis NWR. Because the intent is to restore freshwater marsh (rather than brackish or saline wetlands), determining potentially suitable sites for restoration using the GIS (see Restoration Objectives Report Section 3.3) focused on finding sites with low salinity soils and shallow depth to groundwater (or presumed groundwater based on predicted elevation of base flows) (elevations <2 feet above predicted base flow elevation). Depending on surface water-groundwater dynamics that become established with the implementation of the flow management regime developed in the final restoration plan, some of the potentially suitable area may not support full development of the desired range of wetland conditions without some type of floodplain excavation. Thus, it is difficult to identify potential areas for wetland creation at this scale, and the initial priority should focus on reaches currently containing freshwater marsh.

Restoration of perennial wetlands in areas that may result in higher salinity or alkalinity habitats may provide locations for Sacramento perch reintroduction (see Section 3.4.6.3).

In general, wetland restoration strategies should focus on reconnection of landscape-level linkages for hydrology and dispersal, and restoration of the natural hydrologic regime (Middleton 1999). Horticultural restoration of various dominant and associated plant species may be necessary, but could be used in conjunction with a donor seed bank. According to Weller (1990), “contouring with earth-moving equipment is commonplace in wetland restoration, and should be used to create water depths associated with the desired plant community. Where such work is done on areas with a rich seed bank, soil should be moved off-site and returned as topsoil both for the merits of its organic content and as a seed bank. This will reduce invasions by exotics where they are an issue and the necessity of seeding with cultivated varieties that result in low natural diversity.” Project evaluation is essential both during and after wetland construction to determine compliance with project goals and permit mid-course corrections (Erwin 1990).

3.5.5.4 Alkali scrub and associated habitats

Description and distribution
Alkali scrub and associated alkali habitats occur in areas with saline, sometimes alkaline soils with fine to medium texture. These areas are typically dominated by halophytic shrub plant communities (i.e., plants tolerant of alkaline/saline soils) such as saltbush species and saltgrass. Alkali scrub often intergrades with other alkali vegetation types (alkali meadows, alkali wetlands, alkali grasslands such as alkali sacaton and saltgrass series), depending largely on local variations in soil salinity, texture, and the timing, duration, and magnitude of inundation or surface soil saturation (Holland 1986, Sawyer and Keeler-Wolf 1995, Holland and Keil 1996, Edminster 1998). Alkali claypan vernal pools, and associated plant and invertebrate species, may also occur in the vicinity of alkali scrub.

Alkali scrub is a once-common native vegetation type that is now greatly restricted in abundance in the Central Valley. Historical accounts (as summarized in Chapter 8 of McBain and Trush 2002) indicate that alkali scrub, saltbush scrub, and other alkali vegetation types were once common along the outer margins of the flood basins on either side of the San Joaquin River from Reach 3 through Reach 5. Remnants of this vegetation type currently occur in the project area in the National Wildlife Refuge lands east of Reach 5 (approximately 5 acres was mapped by CDWR as occurring south of the San Joaquin River from RM 125–129, near the confluence of Salt Slough in Reach 5) and in the Alkali Sink Ecological Reserve a few miles south of Reach 2B.

Habitat value
Alkali scrub provides habitat for a number of species that have adapted to these special conditions. It contributes to the diversity of native ecological communities and species occurring in the Central Valley and along the San Joaquin River corridor.

Alkali scrub communities support several species of special-status plants in the San Joaquin Valley, including palmate-bracted bird’s beak, lesser saltscale, Bakersfield smallscale, Lost Hills saltbush, Munz’s tidy-tips, and Jared’s peppergrass (Williams et al. 1998). In addition, alkali scrub provides cover and forage (mostly seeds, but to a limited extent stems and leaves) for several small mammals, a few waterfowl species, and reptiles (Martin et al. 1951), including special-status wildlife species such as the blunt-nosed leopard lizard, San Joaquin kit fox, San Joaquin antelope squirrel, Fresno kangaroo rat, and short-nosed kangaroo rat (Williams et al. 1998). More specific habitat requirements for two of these species are discussed below.

Blunt-nosed leopard lizards are often found in poorly drained, saline or alkaline soils. They inhabit areas with sandy soils and scattered vegetation and are usually absent from thickly vegetated habitats (CDFG 1992). Chesemore (1980, as cited in Williams et al. 1998) found that moderate ground cover (15 to 30 percent) was optimal for the leopard lizard, but that greater than 50 percent was unsuitable. The blunt-nosed leopard lizard Recovery Plan recommends that habitat units of 500 to 1,000 acres should be protected for this species (USFWS 1980).

The Fresno kangaroo rat also occurs in alkali scrub habitat, and seasonally flooded or arid alkali plains. The Fresno kangaroo rat has narrow habitat requirements, only occupying alkali desert scrub communities between 200 and 300 feet elevation (CDFG 1992) within the alkali desert scrub habitat type. Seasonally flooded or arid alkaline plains with alkaline, clay-based soil and sparse growths of grassland or low brush are used (CDFG 2000). Vegetation such as saltbush, iodine bush, saltgrass, and alkali blite provide food and cover for this subspecies (Culbertson 1946). Fresno kangaroo rats shelter in ground burrows located in slightly elevated areas above the level reached by seasonal floodwaters (Brylski and Roest 1994). Availability of suitable burrowing sites in areas free from winter flooding is probably a major limiting factor (Williams et al. 1998). Goldingay et al. (1997) recommended that a minimum of 5,000 hectares is required to support a viable population.

Habitat restoration target

The following reach-specific restoration goals for improving the quality and quantity of alkali scrub and wetlands in the San Joaquin River corridor were developed and prioritized by: (1) identifying current patches of the vegetation type suitable for conservation and enhancement; (2) identifying areas along the river that have physical and chemical characteristics suitable for supporting alkali scrub and wetlands (using a GIS analysis of the DEM assessment area); and (3) using information on habitat requirements for the analysis species described above and published guidelines for alkali scrub and wetland restoration and conservation.

- Maintain or enhance the existing patches of this rare native vegetation and restore additional vegetation where suitable soils and hydrology exist in Reaches 4 and 5.
- As opportunities arise over the longer term, consider additional restoration in lower priority areas in Reach 5 and Reach 4B2.
- Maintain or enhance a diversity of topographic complexity to promote the development of a mosaic of alkali scrub vegetation (e.g., alkali sink, alkali marsh, alkali meadow).
- Consider prioritizing restoration efforts in areas identified in Recovery Plans as critical for special-status wildlife species that depend on alkali scrub habitats. More specifically:
    1. The Recovery Plan for the Fresno kangaroo rat (Williams et al. 1998) promotes the protection of the large block of natural land north of and between the Alkali Sink Ecological Reserve and the San Joaquin River (in Reach 2B).
    2. The Recovery Plan for the San Joaquin kit fox (Williams et al. 1998) suggests areas for priority conservation including (1) expanding Mendota area, Fresno County, and (2) maintaining and enhancing movement between the Mendota area, natural lands in western Madera County, and natural lands along Sandy Mush Road and in the wildlife refuges and easement lands of Merced County. Specifically, maintain and enhance the Chowchilla or Eastside Bypass and natural lands along this corridor through acquisition, easement, or safe harbor initiatives.
    3. The blunt-nosed leopard lizard Recovery Plan suggests preserving and protecting habitat units 500 to 1,000 acres in size (USFWS 1980), for a total of 30,000 acres for the species.

> Three of the 20 areas identified within the Recovery Plan as "Essential Habitat Areas" are within the project area: (a) Firebaugh Area (16,000 acres in private ownership in Reach 3), (b) Madera Area (11,000 acres in private ownership), and (c) Whitesbridge Area (9,000 acres in private ownership)

The GIS was used to identify potential restoration sites that have similar characteristics to existing patches of alkali scrub habitat (high salinity and the presence of clay in the soils that are approximately 6–10 feet above potential base flow levels) (Table 3-23 of Restoration Objectives Report).

Restoration strategies may involve alteration of hydroperiod conditions through flow management or floodplain reconstruction, and horticultural restoration of various dominant and associated plant species found in alkali sink scrub vegetation. If feasible, selection of sites with topographic diversity in addition to suitable soils and hydrology may be desirable for restoration to promote development of a more complex alkali vegetation mosaic (i.e., that includes alkali wetland types as well as just alkali sink scrub). Because of the uncertainties associated with restoration of alkali habitats, flow management may provide the most appropriate large-scale restoration approach. However, smaller-scale pilot efforts to test active, horticultural restoration techniques may also be warranted.

3.5.5.5 Elderberry savanna

Description and distribution
Elderberry savanna is a rare native vegetation type that occurs in silty, sandy soils on well-drained floodplains and terraces throughout the state. This vegetation type is an open, winter-deciduous shrub savanna dominated by blue or Mexican elderberry, with an understory of introduced annual grasses and forbs (Holland 1986). Common associated plant species include bromegrass, yellow starthistle, and horehound (Holland 1986). Without a regular disturbance regime such as grazing, flooding, or fire, elderberry savanna may succeed quickly to mixed riparian forest, where it is generally dominated by California wild grape (Holland 1986). Although we know little about its historical distribution and abundance in the project area, this community currently has very restricted distribution in the San Joaquin River corridor. There are about 63 acres of elderberry savanna on the south side of the channel near the Chowchilla Bifurcation Structure at the junction of Reaches 2A and 2B and small isolated patches in Reach 1A (2 acres) and 2A (3 acres) (McBain and Trush 2002). Elderberry is also found in Reach 1 as a component of the mixed riparian forest and valley oak woodland vegetation types.

Habitat value
The elderberry plant is the host plant for the entire life history of the valley elderberry longhorn beetle, which is listed as threatened under the federal Endangered Species Act. The valley elderberry longhorn beetle historically occurred throughout the Central Valley from Redding (Shasta County) to Bakersfield (Kern County), but population levels are declining (Arnold et al. 1994). Occurrences or signs of the beetle have been reported at several locations within the project area (see Restoration Objectives Report). Guidelines for conserving and improving valley elderberry longhorn beetle populations include: restoring ecosystem processes that benefit riparian vegetation establishment (CALFED 1997); linking isolated areas of habitat that currently support the beetle (CALFED 1997); and planting a mix of native plants associated with the elderberry plants, as studies have found that the beetle is more abundant in dense native plant communities with a mature overstory and a mixed understory (USFWS 1999). In a recent study, Collinge et al. (2001) found that valley elderberry longhorn beetle occurs in drainages that appear to function as distinct, relatively isolated metapopulations, and that signs of the beetle

consistently occur in clumps of elderberry bushes (rather than in isolated bushes) and in branches 5–10 cm in diameter and <1 m off the ground. These results provide additional guidelines for valley elderberry longhorn beetle conservation, as they suggest that conserving or planting groups of elderberry bushes of suitable sizes on a watershed-scale is necessary for successful conservation.

In addition to their value as habitat for valley elderberry longhorn beetle, mature elderberry plants produce edible berries that are an important summer food for many bird and small mammal species. Martin et al. (1951) identified 14 species of songbirds that use elderberries for 2 to 50 percent of their diet, and three mammal species that use elderberries or the twigs and foliage of the plant for 2 to 5 percent of their diet.

Habitat restoration target

The following reach-specific restoration goals for improving the quality and quantity of elderberry savanna in the San Joaquin River corridor were developed by: (1) identifying current patches of the vegetation type suitable for conservation and enhancement; (2) identifying areas along the river that have physical and chemical characteristics suitable for supporting elderberry savanna; and (3) following the guidelines for valley elderberry longhorn beetle conservation discussed above.

- Expand existing patches or add new patches to the complex of patches found in Reach 2B just downstream of the Chowchilla Bifurcation Structure. Review of existing soil and topographic characteristics of the existing patches of elderberry savanna indicate that there are approximately 520 acres in Reach 2B that may be suitable to support elderberry savanna. Population dynamic studies of valley elderberry longhorn beetle suggest that linking the patches of elderberry savanna in this reach would provide an important center for the dispersal of elderberry and beetle populations (Collinge et al. 2001).
- Expand or add new patches adjacent to the existing patches in Reach 1A and 2A. Expansion of these patches would also serve to promote the dispersal of elderberry and valley elderberry longhorn beetle populations. Larger, contiguous patches of elderberry savanna would serve as foraging habitat and provide cover along the river corridor for wildlife species.
- Extend the distribution upstream or downstream of existing patches to reduce the distance between patches of elderberry savanna by adding new patches in Reaches 1 and 2. As described above, linking these patches would provide opportunities for the dispersal of elderberry plant species, associated elderberry savanna, and valley elderberry longhorn beetle populations, and would provide foraging and cover habitat for wildlife.

According to the vegetation mapping conducting by CDWR (2002), the GIS analysis conducted by Stillwater Sciences, and the results of the Stillwater Riparian Recruitment Model, there are approximately 60 acres of existing elderberry savanna that are suitable for conservation or enhancement and potentially 3,000 acres along the river corridor that appear to have the soil and elevation characteristics required to support the restoration of elderberry savanna. Reaches 1A and 2 have the greatest potential for the restoration or creation of elderberry savanna.

The restoration of elderberry savanna along the San Joaquin River will likely require a combination of preserving existing patches as a source of elderberry and valley elderberry longhorn beetle population dispersal, and horticultural restoration to expedite recolonization of elderberry and associated plant species. Horticultural restoration techniques are well developed for elderberry in the California and the Central Valley (Oldham and Valentine 1989, Stanley et al. 1989, Alpert et al. 1999), presumably because horticultural restoration of elderberry for valley elderberry longhorn beetle habitat is often required as mitigation for various development projects. While horticultural restoration techniques for the species are well established, little is known about natural seed dispersal and establishment processes for elderberry. This limits our ability to predict the trade-offs between using horticultural restoration entirely vs. using horticultural techniques in a more limited fashion to establish some additional patches initially, but then relying on natural dispersal and establishment of new plants to expand existing patches or establish new patches of elderberry savanna.

3.5.5.6 Central california sycamore alluvial woodland

Description and distribution
Sycamore alluvial woodland is a winter-deciduous broad leafed riparian woodland community type, dominated by California sycamore with open to moderately-closed canopy (Holland 1986). Valley oak, as well as Fremont cottonwood, red willow, and Gooding’s black willow can also occur (CDFG 1997). Other woody tree species found within this community type are California buckeye and blue (Mexican) elderberry. The understory is often made up of mule-fat, coffeeberry, buttonwillow, and introduced grasses (Holland 1986). Sycamore alluvial woodlands typically occur along braided, depositional channels of intermittent streams, on cobble or boulder substrates.

In low-gradient rivers, such as the San Joaquin, sycamore alluvial woodlands occur in broad valleys where pronounced stream terraces (usually over 500 ft wide) were formed from fine-grained alluvium (CDFG 1997). The only known sycamore alluvial woodland habitat within the study area is located along Little Dry Creek (Reach 1A; the confluence with the San Joaquin River occurs near RM 260.5), and is approximately 29 acres in size in a narrow band 1-mile long along the creek (CDFG 1997). Because Little Dry Creek retains moisture year-round, wetland plants such as cattail and tule have established within the stand (CDFG 1997). This location is one of only 17 known stands greater than 10 acres of Central California sycamore alluvial woodland, and one of only 11 stands known of the rare “interior alluvial” phase of this vegetation type (CDFG 1997). The largest patch of Central California sycamore alluvial woodland in the state occurs on Los Banos Creek, Merced County (426 acres), in the general vicinity of the study area.

Habitat value
Sycamore alluvial woodland habitat provides cover for many riparian bird species, including Cooper’s hawk, Least Bell’s vireo, and Swainson’s hawk, as well as foliage-roosting bats. Because these habitats often occur at the confluence of tributary streams with larger river channels, sycamore alluvial woodlands also provide important habitat connectivity from upper drainage areas to the valley floor.

Most Swainson’s hawk nests occur within 1 mile of the riparian zone (Bloom 1980), usually in the upper canopy or lateral branches of tall trees such as sycamores or cottonwoods. Swainson’s hawks were observed at the sycamore alluvial woodland habitat on Little Dry Creek (JSA 2001). Population increases in Owens Valley suggest that Swainson’s hawks can respond to improved habitat conditions (Woodbridge 1998). Other species that occupy the same mature tree and gallery forests of riparian systems and may benefit from improved nesting conditions for Swainson’s hawks include yellow-billed cuckoos, yellow-billed magpie, long-eared owl, great horned owl, red-tailed hawk, white-tailed kite, Cooper’s hawk, great blue heron, and black-crowned night heron (Woodbridge 1998).

Breeding western red bat females are often found in association with cottonwood/sycamore riparian habitat along large river drainages in the Central Valley (Pierson et al. 1999 and 2000). It is believed that this non-colonial species roosts almost exclusively in foliage under overhanging leaves. Preliminary investigations of the western red bat suggest that it is highly associated with cottonwood and sycamore riparian forest, and is more abundant in more mature stands (Pierson et al. 2000).

Habitat restoration target

The following restoration goals for improving the quality and quantity of sycamore alluvial woodland in the San Joaquin River corridor were developed by: (1) identifying current patches of the vegetation type suitable for conservation and enhancement; and (2) identifying areas along the river that have physical and chemical characteristics suitable for supporting sycamore alluvial woodland.

- Preserve the existing sycamore woodland community found in Reach 1A, and promote natural geomorphic conditions within the downstream end of that reach to encourage expansion or establishment of new stands.

The specific physical conditions that support sycamore alluvial woodlands make it a rare vegetation type, even historically (Farquhar 1966, as cited in CDFG 1997). In addition to requiring an alluvial, intermittent stream-bench location, sycamore alluvial woodland stands require periodic flooding, high moisture conditions for seedling establishment, and low grazing pressure (CDFG 1997). Although anthropogenic impacts have undoubtedly exacerbated the situation and decreased the suitable area for recruitment, creating these conditions artificially is difficult given our current understanding of the community.

3.5.5.7 Vernal pools

Description and distribution

Vernal pools are seasonal wetlands that form in shallow, poorly drained depressions outside of the river channel (typically in grasslands), and alternate on an annual basis between drought conditions and periods of standing water (Keeley and Zedler 1998). They are predominantly rain-fed and tend to form perched water tables above duripan or claypan soils (Chetham 1976, as cited in Smith and Verrill 1998). The temporary nature of vernal pools favors organisms that complete an annual life cycle and can withstand both wet and dry periods, resulting in a large number of vernal pool specialists and California endemic flora and, to a lesser extent, in endemic invertebrate fauna (Keeley and Zedler 1998).

Though greatly reduced from their historical distribution (McBain and Trush 2002), remnant vernal pool complexes are found throughout the Central Valley, and are those in teh vicinity of the San Joaquin River typically of the northern claypan type. Many of these pools border extensive alkaline wetlands, particularly near the San Luis National Wildlife Refuge Complex (bordering Reaches 4 and 5). In addition to the claypan vernal pools mentioned above, northern hardpan vernal pools also occur in the vicinity of, but outside of, the immediate project area to the north and south of Reach 1A.

Habitat value

Many of the rare and/or special-status plant, invertebrate, and amphibian species within the project area are associated with vernal pools (McBain and Trush 2002). Thirteen vernal pool plant species, including species of saltbush, navarretia and Orcutt grass, and six vernal pool wildlife species are known to occur in the project area (McBain and Trush 2002). Longhorn fairy shrimp is one of approximately four shrimp species that depends on vernal pools in the San Joaquin basin. Their entire life cycle occurs within seasonal pools, and they are able to withstand years of desiccation before returning to an active state when pools form again. Amphibians, including the California tiger salamander and western spadefoot toad, rely on these ephemeral wetland areas for the reproductive portion of their life cycle.

Additionally, vernal pools provide feeding and roosting habitat for both resident and migratory birds, including many species of waterfowl and shorebirds. Although they are limited both in spatial and temporal extent, vernal pools provide short but very productive periods of invertebrate prey abundance during the springtime, which is critical to waterfowl survival and recruitment (Silveira 1998). As pools begin to dry, they are used for a variety of other purposes. Cliff swallows glean mud from vernal pools for nest material, tricolored blackbirds forage in dry pool beds, and lesser nighthawks nest in dry pool beds (Silveira 1998).

Habitat restoration target

The following restoration goals for vernal pools in the San Joaquin River corridor were developed by reviewing the scientific literature regarding this rare ecosystem and the species that are specially adapted to it.

- Avoid impacts on, and protect and enhance where possible, existing vernal pools within the restoration planning area. Where active restoration efforts are to occur, it is critical to survey for vernal pools prior to construction, to avoid both direct construction impacts and localized hydrologic impacts that may affect vernal pool formation. If the pools cannot be avoided, then creation of vernal pool complexes as mitigation must be considered, recognizing the potential difficulties and uncertainties associated with active creation of this rare habitat.
- Consider appropriate grazing regimes when developing management plans for vernal pools. All special-status fairy shrimp species are open water, planktonic forms (D.C. Rogers, pers. comm. 2003). If grazing is completely eliminated from the restored areas, vernal pools tend to fill with vegetation, especially invasive grasses, and this promotes habitat for mosquitoes (D.C. Rogers, pers. comm. 2003). If the sites are overgrazed, manure in the runoff often causes nutrient enrichment and produces a similar effect (D.C. Rogers, pers. comm. 2003).

Vernal pool complexes have been greatly reduced from their historical extent. Fragmented and isolated patches still occur throughout the Central Valley. Within the project area, these areas are typically found near the San Luis National Wildlife Refuge Complex bordering Reaches 4 and 5. Although they are typically associated with claypan soils, the microtopography responsible for their formation is difficult to identify via the coarse-scale GIS analysis used to map other vegetation types in the project area (see Restoration Objectives Report). Site-specific field observations should be employed when restoration planning has proceeded to a more refined scale (e.g., when sites for active re-construction have been identified).